CASSELL'S TECHNICAL MANUALS.

DRAWING
FOR
STONEMASONS:

Containing a Description of the Construction of the Subject of each Study and the method of Drawing it; with Elementary Lessons in Freehand and Object Drawing, and a concise History of the Art of Masonry.

WITH
SIX DOUBLE AND TWENTY-FIVE SINGLE PAGES
OF ILLUSTRATIONS, ADAPTED FOR DRAWING COPIES,
DRAWN ON WOOD BY THE AUTHOR.

BY
ELLIS A. DAVIDSON,
AUTHOR OF "LINEAR DRAWING," "PROJECTION," "DRAWING FOR
CARPENTERS AND JOINERS," "BUILDING CONSTRUCTION,"
"DRAWING FOR MACHINISTS," "PERSPECTIVE,"
ETC. ETC. ETC.

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INTRODUCTION.

THE subject of "Building Construction" having been treated of generally in another volume of this series, a number of sectional manuals, devoted to the special branches of industry concerned in the building trades necessarily follow—commencing with "Drawing for Carpenters and Joiners," which was published some months ago, and which has been hailed with the greatest satisfaction by a large number of artisans and science teachers.

The present volume is devoted to such branches of drawing as are of immediate importance to Stonemasons. A sequel to this will be found in "Gothic Stonework," whilst "Drawing for Bricklayers" will form a companion to both the last-mentioned.

Each of the Technical Manuals is, as far as possible, complete in itself; but it must be clear to every reflecting mind that this does not imply that either one of the books can contain all the required information. They must be considered as landmarks in the great highway of knowledge, each chapter being, as it were, a finger-post to direct the traveller; and therefore the student is urged to make himself in the first place practically acquainted with the volumes on "Linear Drawing" and "Projection," on which all the subsequent studies are based, and to work with diligence and care from those comprehended in the present group; the separate branches, such as model drawing, perspective, freehand drawing, &c., may then be followed up by means of the manuals devoted specially to these subjects.

The student is above all warned that there is no royal road to learning; the path may be rendered in some degree less rugged, certain of the obstacles may be removed—and it has been the object of the author's life to "roll away the great stone from the mouth of the well"—the well of knowledge—so that all who come may drink from its vivifying waters; but the efforts of all teachers and writers must fail, unless those for whose advantage those efforts are made exert themselves so as to receive the benefits thus held out to them.

The avidity with which our artisans have seized on the previous volumes, and the interest they have shown in them, their adoption in numerous colleges and science schools, the circumstance that they have been placed on the list of recommended text-books by the examiners for the Science and Art Department, and are also given as "Queen's prizes," are sources of the greatest encouragement to the author and publishers, and it is hoped that the present manual may be found a worthy companion to its predecessors.

ELLIS A. DAVIDSON.

DRAWING FOR STONEMASONS.

A CONCISE HISTORY OF MASONRY.

ALTHOUGH the purpose of this book is to teach drawing of precisely the kind necessary for stonemasons, still it is hoped that a brief sketch of the history of masonry will not be unacceptable.

The art of building in stone is one of the greatest antiquity, dating possibly from the first human family. We find that Cain, driven by his sin to become a wanderer from his native place, and when a son had been vouchsafed to him, "builded a city," and called it, after the name of his son Enoch (Hebrew, *Dedication*). We have, of course, no data to give us the slightest idea of the extent of the buildings which constituted this primitive city, but, from the word used in the original, it is most probable that permanent structures *in the form of caves* were erected.

There can be no doubt that from the moment when our first parents were driven from Eden, to till the ground and to labour, they must have felt the necessity for some place where their children might be nurtured and protected from the rays of the sun.

The umbrageous trees and the skins of animals might at first have proved sufficient; but a better shelter would at once have been suggested by holes in rocks or natural caves. These, however, could not be found everywhere.

What is more natural than that wooden huts should be erected, and that these, being perishable, should, when circumstances allowed, be superseded by stone buildings? And thus the trunks of trees, and beams laid across them, probably gave the original ideas for the columns and architraves of the subsequent erections in a more permanent material.

Amongst the earliest nations of the world heaps of stones were regarded as memorials of some event, or as emblems of the permanency of the agreement entered into. Thus we find Jacob took a stone and set it up for a pillar, and said to the people, "Gather stones," and they took stones and made a heap, and each party called it by a name which, in his own language, signified "the heap of witness." Several such instances occur in sacred history.

Amongst rude and barbarous people, there seems in all ages to have existed this desire to erect huge masses of stones, either to commemorate some triumph, or for the exercise of their religious rites; and the early history of almost every nation contains records of some such structures.

Of the early history of stone-work, Mr. Ashpital says: "The necessity for defence against predatory tribes seems to have given the next impulse to building in stone; and to this we probably owe those extraordinary walls called Cyclopean or Pelasgic. These consist of huge polygonal blocks of stone carefully cut, so as to fit exactly to each other without mortar, forming walls which must have been impregnable at that time."

An idea of their size may be gathered from the fact that in the Etruscan walls at Rusellæ, Mr. Dennis measured a stone 12 feet 8 inches long by 2 feet 10 inches high. Most of the stones forming these walls would weigh from six to eight tons. It seems very difficult, considering the deficiency of machinery at the period, to imagine how they were hoisted. Pausanias, describing those of Argolis, says: "The walls, the only remains of the city left, are the work of the Cyclops, and are made of rough blocks of such a size that a yoke of mules would be unable to move the smallest."

The masonry practised in Assyria possessed this peculiarity—that, excepting at the angles, it formed only a facing to the immensely thick walls, which were filled up in a manner to be subsequently described; and it is especially interesting to us from its great antiquity.

Mr. Layard, to whom the world owes so much for his discoveries in Assyria, tells us that 600 years before the Christian era, Nineveh ceased to be a city, and Assyria an empire. Cyaxeres, at the head of a vast army of Babylonians and Persians, captured Nineveh after a short siege, destroyed its walls and palaces, and left it what it has remained to this day—a heap of ruins. The Assyrians, after the destruction of their capital, became subjects of the King of Babylon, and appear no more in history as an independent people.

The main cause of the utter disappearance of Nineveh is to be found in the circumstance that the buildings were not erected of stone, but merely faced with it; and not always this, for their palaces, public buildings, and private dwellings were erected of bricks made of clay, mixed with chopped straw—in most cases dried in the sun; but, evidently, stone was not a general building material, for in erecting the Tower of Babel we find the people saying, "Come, let us make bricks, and burn them thoroughly" (thus implying that *thorough* burning was not usual); "and they had brick for stone, and slime (*bitumen*) had they for mortar."

Marble, alabaster, and kiln-burnt bricks, sometimes painted and sometimes glazed, were used by the Assyrians in their principal buildings, but only in the way of ornament. The whole of the upper portions of the buildings were of wood, and hence, when the buildings were once deserted, the upper portions decayed and fell in. The sun-burnt bricks, which formed as it were the core of the walls, became earth again. Their support thus being withdrawn from the slabs, the ruins assumed the appearance of mere natural heaps or mounds rising in the plain, upon which grass grew and corn might be sown. And such have been the ruins of Nineveh for more than 2,000 years.

The Assyrian palaces and public buildings were erected in terraces thirty or forty feet above the level of the surrounding country. These platforms appear to have been supported by solid masonry of limestone. The line of elevation was broken by flights of steps or inclined ways, by which the terrace was reached. "The object," says Mr. Layard, "of raising these great platforms, which must have demanded scarcely less labour and expense than the superstructure they were destined to sustain, was twofold—to give to the royal or sacred edifices additional dignity and grandeur, and to secure, in a climate remarkable for its intense heat during the summer months, as much coolness as possible. In some cases, too, especially in the lowlands of Babylonia, they may have served both as a means of defence and to protect the buildings against the effects of the inundations to which that country is subject." Several of the alabaster sculptured slabs, and of the human-headed bulls brought from Nineveh, may now be seen in the British Museum, and copies of them form parts of the admirable reproductions in the Nineveh Court in the Crystal Palace at Sydenham.

The Egyptians seem not only to have used gigantic masonry, but also to have had the power of working, carving, and polishing granite to a marvellous degree. A strange fact connected with their masonry seems to be, that the whole work was executed with copper, or rather bronze tools, which seem to have answered their purpose better than even our best or hardest steel. Such seems to have been the facility with which they worked this untractable material that they were not content to cut and polish huge slabs and masses of granite, but they covered them all over with the most delicate and sharp-cut hieroglyphical inscriptions.

Mr. Owen Jones, to whom we are indebted for the admirable reproductions in the Egyptian Court at the Crystal Palace, says: "Egyptian architecture—or rather Egyptian Art—for painting, sculpture, and architecture are so intimately united that they are inseparable—is the parent of every other. Undoubtedly the most ancient, its remains are still the most abundant. The Egyptians built for immortality, and obtained it. Whilst obedient to religious laws which limited the direction of their art, they combined the highest sublimity of conception with the most refined and delicate finish in execution."

Whilst they originated, they excelled at the same time all that followed after; they are inferior only to themselves. In every other nation, art exhibits its progress in the same phases, namely, a rapid ascent from its infancy to the culminating point of perfection, from which there is a slow, lingering decline; but in Egypt, the farther we go back the more perfect is the art. We are not even acquainted with its culminating point, much less with any trace of its infancy. In the most perfect temples which have been discovered there are stones built in the walls, with hieroglyphics on the inner side of a higher character of art than can be found on existing monuments. These were evidently stones from ruins of more ancient buildings. Two kinds of walling were common in Egypt from the earliest to the latest period*—one formed of vast rectangular blocks of stone laid in parallel courses, the other of sun-dried brick. The latter was used for walls of towns and sacred precincts, and occasionally for pyramids, but never for any part of a temple.

The stone walls were of prodigious thickness and the blocks of gigantic size; but in the early Theban works we find little of that interlacing of the stones, or *bond*, which is so essential to stability. This partly accounts for the ruined state of some of those tremendous masses—gigantic walls of the most massive construction, and absolutely rent asunder. The masonry of the pyramids, however, appears to be excellent. Unlike the migratory Pelasgi, to whom reference has already been made, the Egyptians seem to have used mortar from the earliest ages. The blocks were also commonly united by wooden dovetailed cramps about a foot in length.

The columns ordinarily employed were of such colossal dimensions that they were necessarily *built up*—each cylindrical layer being composed of several stones. They were commonly constructed with blocks rough-hewn externally; the shaft was afterwards finished, and the capital chiselled to the proposed design. A whole rough-hewn colonnade is still seen in the Isle of Philæ.

Walls appear to have been left rough till they received their sculpture, and Herodotus† intimates that a similar method was followed at the Great Pyramid—having been carried up to the full height, it was finished off from the summit to the base.

Mr. George Godwin, in his admirable "History in Ruins," says: "The most ancient structure remaining is the Great Pyramid—one of those mighty works wherein, as Dénon says, 'men seem to measure themselves with nature.'" Herodotus, who visited Egypt about 450 years before the Christian era (some say 500), or more than 2,300 years ago, spoke even then with uncertainty as to its date. It is, however, usually ascribed to Suphis (or Cheops), who reigned soon after Menes, and may be called 4,000 years old—Bunsen says 5,000.

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* Wathen's "Arts and Antiquities of Egypt."

† Herodotus, a celebrated Greek historian, born at Halicarnassus, 484 B.C., and died 408 B.C.

Herodotus says: "The ascent of the pyramid was regularly graduated by what some call steps, and others altars. Having finished the first flight, they elevated the stones by the aid of machines constructed of short pieces of wood; from the second by a similar engine to the third; and so on to the top. The summit of the pyramid was first of all finished; descending thence they regularly completed the whole"—that is, they placed plates of stone slantingly from one step to the other, and so produced a uniformly slanting mass.

The dimensions of the Great Pyramid have been differently stated, the mounds of rubbish rendering it difficult to obtain accurate measurements. Those taken by Colonel Vyse's operations in 1837, probably nearest the truth, are as follow:—Original base, 764 feet; actual base, 746 feet; original inclined height, 611 feet; actual perpendicular height, 450 feet.

The original perpendicular height, therefore, supposing the pyramid to have been carried up to a point, was about 480 feet, or 43 more than St. Peter's at Rome, and 110 more than St. Paul's Cathedral, London. The area covered was almost 13½ acres, but the approximate size of the mighty mass will be better understood if it is described as a solid pile, the base of which would occupy the whole square of Lincoln's Inn Fields, and the height of which would exceed that of St. Paul's. The stones employed in the construction vary from five to thirty feet in length and from three to four feet in height.

According to Pliny,* 366,000 men were employed on its erection for twenty years, and Herodotus tells us that an inscription on the exterior stated the expense of providing them with radishes, onions, and garlic amounted to 1,600 talents of silver (£345,600). Ten years were employed in making the road through which the stones were to be drawn, the quantity of which Colonel Vyse estimates at 3,316,000 tons.

Thus, thousands of enormous stones, all accurately squared and adjusted, were here elevated to hundreds of feet above the ground, and each was hoisted up, step by step, until it reached its place.

The pyramids, however, although they attest the resolution of the founders, reflect but little honour on the Egyptian nation. One can scarcely contemplate these structures without the conviction that they were the work of an enslaved and driven race. Such vast piles of mere stone and mortar could never have been reared in Greece or Rome. At the Parthenon or at St. Peter's you view the result of the labours of a multitude of ingenious and thinking men, each contributing the skill derived from a life devoted to his art; but in the erection of the pyramids little else was required of the artificers than physical exertion and obedience to the taskmasters—and, indeed, nothing was done for the labourers which could elevate or educate them. All we find in relation to the workmen is a record of the amount spent on onions for them!

How different this from the present age, when all civilised nations are vying with each other in the promotion of the instruction, the mental improvement, and social well-being of the working classes!

The first material used by the Greeks in their buildings was timber. They then employed bricks, the art of making which they learnt from the Egyptians; common stone followed next, and when they had accomplished the complete glories of their style, they adopted marble. The sort called Parian was the most admired, but this was principally used in sculpture. Pausanias* also tells us that in the earlier times several temples were built of *bronze*. Stones of immense size, after the manner of the Egyptians, were also used by the ancient Greeks. In later periods smaller stones were used; these were of various forms, having in some cases four, and in others five or six sides, and were joined with the utmost care and nicety.

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* Pliny—Caius Plinius Secundus—a great Roman writer, who lived in the first century. He was suffocated by the vapours caused by the eruption of Mount Vesuvius in A.D. 79.

Materials used by the Greeks.

As architecture and other arts advanced, the Greeks used cubical and oblong stones, with which they constructed their walls, says Vitruvius,† in two principal methods—one called *Isodomon*, in which all the courses were of an equal thickness; and the other, *Pseudisodomon*, in which they were all unequal. The first, or true manner, was always used in their grandest buildings, as being the most beautiful; and the latter, or false method, where beauty of appearance was of less consequence.

Greek walling.

Another and still inferior mode of walling was also used by the Greeks for works of lesser consequence; this was called *Emplecton*. The front stones only of this manner were wrought, and the interior left rough and filled in with stones of various sizes or rubbish. This style was principally used in walls of great thickness, such as those surrounding cities. In some instances the walls were built of bricks or common stone, and faced with marble.

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* Pausanias, a Greek historian who lived in the second century. He wrote "Accurata Græciæ Descriptio," in which he gives a very minute account of the topography of Greece, and of its buildings and ruins, as seen by himself.

† Vitruvius, a celebrated Roman architect, born about 80 years B.C. (See Building Construction," page 24.)

Cement seldom used by the Greeks.

Cement was seldom used by the Greeks in their best works, as the size and weight of the blocks and the great exactness with which they were squared were sufficient for solidity, and of course made more perfect and complete joints.

Ornament should be appropriate to position.

The Greek architects of the best period were judiciously careful that the ornamentation should in every case accord not only with the purpose to which the building was to be devoted, but that it should be appropriate to the situation in which it was to be placed. Thus they never built a prison in the Corinthian (or most graceful and highly decorated) style, nor a theatre in the severe and solemn Doric. The external ornaments are bold and sparingly distributed, and as they are to be exposed to light, they stand out in high relief from the surface, so as to cast bold shadows. This is called Alto-relief, whilst the system of ornamentation used for less exposed situations was that called Bas-relief, in which the figures or objects project only partially from a flat surface, like a raised painting. Both of these styles may be studied from the model of the Parthenon, or Temple of Minerva, at the Crystal Palace, in which the ornamental sculpture will be observed in its place, whilst a portion of it is placed of the size of the originals along the walls of the gallery. The originals, called the Elgin Marbles, may be seen in the British Museum. Amongst these will be seen several figures—such as Theseus, or Hercules, Ilissus, or river-god, which formed portions of the groups in the pediment, or triangular portion surmounting the pillars of the portico. These were absolutely separate from the background. (Figures placed in this

Alto-relief.

Bas-relief.

The Parthenon.

The Elgin Marbles.

manner may be seen in the pediment of the Royal Exchange, which faces the Poultry, London.) The Elgin Marbles* also comprise the celebrated Frieze —a broad horizontal band of sculpture which was placed around the outer wall of the "cella," or principal chamber of the temple, within the cloister or covered walk which surrounded the building. This remarkable work represents the solemn procession to the Temple of Minerva during the Panathenic festival, and has never been equalled for elegance of composition, and the variety and gracefulness of the figures. It is executed in low relief, in order to adapt it for its precise position ; for as it was placed high up on a wall, in a narrow corridor, the lower part of the figures would, had they stood out in high relief, have hidden the upper from the vision of the spectator, who was precluded from stepping back to view them at a distance ; and, further, the frieze, placed as it was within the colonnade, received its light from between the columns, and by reflection from below, and therefore figures projecting far from the background would have cast shadows in an uncertain or contradictory manner.

Frieze from the Parthenon.

This exquisite frieze occupied slab after slab, a space of 524 feet in length. The remains of it in the British Museum, on slabs and fragments of marble, are to the extent of 249 feet, besides 76 feet in plaster casts. These sculptures were designed by Phidias,† and were executed by him, or under his superintendence.

The masonry of the Greeks was, as has been said, executed in the most beautiful marble, the workmanship being worthy of the costly material. The joints, &c.,

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* The Elgin Marbles were brought from Greece by Thomas, seventh Earl of Elgin, and acquired from him by the nation for the British Museum in 1816 for the sum of £36,000.

† Phidias, a famous sculptor of Athens. He died B.C. 432.

Character of Greek masonry.

Arch not used as a feature in Greek architecture.

were worked with the most exquisite refinement and truth, whilst the artistic portion has not been surpassed in any subsequent period. "It seems difficult to believe," says Mr. Ashpital, "that so enlightened a people were ignorant of the use of the arch, especially as it is clear that it was known, not only to the Egyptians, but was used in Nineveh. However, no example of a Greek arch exists at this time as an architectural feature, although for necessary purposes (as covering drains), and concealed in the walls (as discharging arches), examples are to be found in Greek works. It is probable that, as they had plenty of marble in blocks of almost any size, they preferred to use it in horizontal bearings to working it into arched forms."

Roman masonry.

It was, however, different with the Roman masons: although, it is true, many of their temples were Greek in character, and most of them rivalled those of that nation in size and in the vastness of the material employed: the blocks of stone, for instance, in the architrave of the Temple of the Sun measure 16 feet 6 inches long, 9 feet 6 inches high, and about 6 feet thick, weighing nearly 50 tons. But in general character there was less of that ponderous strength that characterised the Egyptian and Grecian Doric, and much more science in the construction, especially as regarded economy, whilst in point of artistic beauty they were far below the Greeks.

Early Roman buildings.

The Early Romans can scarcely be said to have possessed any style of building of their own, but borrowed their ideas from the Etruscans (who inhabited a part of Italy now known as Tuscany), and from the Greeks at a later period. In the time of Romulus their buildings would seem to have been of the rudest description, their dwelling-houses being composed principally of straw : and even at a somewhat later period their temples were only small square erections, scarcely large enough to contain the statue of their idol.

Ancus Martius was the first king who commenced works of a larger class, requiring skill in their construction ; and his first attempt was the building of the city and port of Ostia, at the mouth of the Tiber. Tarquin the Elder brought with him the skill and enterprise of the Etruscans, and set about improving the city with energy and perseverance. His first work was to erect the grand circus : he also constructed the walls of the city with large hewn stones, and commenced the great Cloaca, or public sewer. This great work, which was considered one of the wonders of the world, was constructed of wrought stones, and was of such dimensions that a wagon loaded with hay could pass through it, and was carried through rocks and under hills, overcoming every engineering difficulty.

Cloaca Maxima, or great Roman sewer.

Cements used by the Romans.

To what nation or race the invention of the arch may be attributed, it is clear the Romans were the first to bring it into general use, and they were the first in Europe to use the true dome in covering their temples. Besides this, they had not only good lime, but plenty of puzzolana,* and therefore their mortar and cement were of first-rate quality. To these advantages we may attribute the vast works which to the present day amaze the spectator, who cannot view the Roman cloacæ, aqueducts, amphitheatres, basilicæ, walls, towers, tombs, domes, harbours, &c., without wonder at the enterprise of the people and the skill of their masons.

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* ***Puzzolana*** A substance formed of volcanic ashes more or less compacted. It derives its name from Pozzuolo, as also Pulvis Puteolanus, from Puteoli, situate near Mount Vesuvius, from which these ashes are ejected, and in the vicinity of which it abounds. It occurs in various colours—white, red, or black, reddish, or reddish-brown, grey, or greyish-black That of Naples is generally grey; that of Civita Vecchia is more generally reddish, or reddish-brown. The red variety is the proper puzzolana ; the black and the white

Skill of Roman masons.

As the whole subject of Gothic architecture forms a separate volume of this series, it is not intended here to enter fully into that subject; into the Byzantine, out of which it grew; nor the Saracenic, which was a rendering of architectural and ornamental elements under certain religious restrictions: a brief mention of the characteristic features of the period are therefore only necessary.

Middle Age masons.

After the ruin of the Roman Empire, and the irruption of the savage hordes over the whole of civilised Europe, the art of masonry, like all others, declined to the lowest ebb. Had it not been, in fact, for the erection of rude forts and towers, it would have become extinct. In England we owe its revival to the Normans, who came over with William I. in 1066; and next, no doubt, to the Crusaders, who had witnessed with admiration the marvellous lightness of the buildings in the East, and who brought back with them the arts and learning of the Arabians, especially their mathematical science. From these sources, no doubt, Pointed architecture took its rise, and massive cylindrical pillars, composed of many small pieces of stone, small circular-headed windows, walls of vast thick-

Mediæval architecture.

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sorts are called in Italy *lapillo* or *rapillo* The ashes which overwhelmed Pompeii now form an immense bed of white puzzolana. The surface of this substance is rough, uneven, and of a baked appearance; it comes to us in pieces, from the size of a nut to that of an egg. When mixed with a small proportion of lime it quickly hardens, and this induration takes place even under water. The ancients were well acquainted with this substance and its properties, and among them its principal use, as it has been also in modern times, was that of mixing it with their cements for buildings sunk under the sea. As it hardens and petrifies in water, it is of particular service in making moles and other buildings in maritime places.

ness, with very shallow buttresses, and plain groining without ribs, became changed to light-shafted piers, and delicately-moulded arches. Windows, rich with varied tracery, panelled walls, with bold buttresses, surmounted by niches and crowned by pinnacles, and groined roofs fretted with a network of ribs, and studded with richly-carved bosses at the points where they crossed each other, were gradually introduced, until the whole system of what has been termed the "Gothic" style was perfected.

Window tracery.

In the sixteenth century a revival of classic architecture took place. The Gothic style had become much debased, and Roman or Italian styles were introduced into this country by Inigo Jones,* whose splendid works at Greenwich, Whitehall, and Covent Garden will ever secure him a place among names of the highest reputation.

Revival of classic architecture.

Inigo Jones.

Sir Christopher Wren,† an eminent mathematician, philosopher, and architect, executed very many of the finest buildings in London and other parts of England in the modern style. St. Paul's Cathedral in London, inferior to none but St. Peter's in Rome in point of magnitude, is justly con-

Sir Christopher Wren.

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* Inigo Jones was born in the neighbourhood of St. Paul's, London, in 1572 His great aptitude for drawing attracted the attention of the Earl of Pembroke, who sent him abroad for four years to study the masterpieces of architecture in France, Germany, and Italy. In 1612 Jones revisited Italy, further to improve his style, and on his return to England he was appointed Surveyor-General of the Royal Buildings. His masterpiece is considered to be the Banqueting House at Whitehall. He also built the church of St Paul, in Covent Garden, Ashburnham House, Surgeons' Hall, &c He died in 1653

† Sir Christopher Wren was born in Wiltshire in 1632. He was educated first at Westminster School, and subsequently at Wadham College, Oxford. After the great fire in 1666, Wren drew plans for the entire rebuilding of London; few, however, of his recommendations were adopted. He was the architect of St. Paul's; and in 1710, in his seventy-ninth year, superintended

sidered one of the finest works of modern times. The exterior cupola of St. Paul's is constructed of oak, and is sustained by a cone of eighteen-inch brickwork, which has a course of stone the whole thickness—every five feet. Sir Christopher Wren did much to improve masonry, the works at St. Paul's and other public buildings carried out under his superintendence being executed in a very superior manner. Besides this, with the assistance of Grinling Gibbons,* he formed an excellent school of architectural carvers. He was very particular in the choice of his stone. It is said that when the stone for St. Paul's had been quarried in the island of Portland, it was exposed to the weather on the sea-beach for three years before he permitted it to be used ; and the result of his care is that amongst all his buildings there is scarcely a failure or a defective block.

St. Paul's Cathedral.

The art of masonry was well upheld in the eighteenth century by Vanbrugh, Hawksmoor, Gibbs, and Lord Burlington. These were followed by Sir William Chambers,

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the placing of the highest stone in the lantern by his son, the erection having occupied thirty years. Besides this, he built fifty churches, the late Royal Exchange in 1667 (the present was built by Mr. (now Sir William) Tite, and opened by Her Majesty Queen Victoria in 1844) ; the Custom House in 1668 , Temple Bar in 1670 ; the Monument in 1671 ; the Royal Observatory, Greenwich, in 1675 ; Chelsea Hospital, 1690 ; Greenwich Hospital, 1696 ; Marlborough House in 1709 ; the upper portions of the towers at the west front of Westminster Abbey in 1713, &c. &c. &c. He died in his chair in 1723, aged ninety years. The following inscription marks his tomb in St. Paul's—"Dost thou seek his monument? look around."

* Grinling Gibbons was of Dutch descent—if not, indeed, born at Rotterdam, concerning which there has been much dispute. He was born in 1648, and distinguished himself in carving at a very early age, when we find him living in La Belle Sauvage Yard, Ludgate Hill—the spot on which stand the works of Messrs Cassell, Petter, and Galpin. Here he exhibited a pot of flowers carved in wood, so exquisitely delicate, that the leaves vibrated as the coaches passed. He was subsequently recommended to Charles II., and executed a great portion of the carving in the chapel at Windsor. He also executed the carving in the choir of St. Paul's. He died in 1721.

who built Somerset House; Dance, the architect of Newgate Prison; Sir John Soane, who built the Bank of England. But shortly after cement works became so general that masonry suffered. "Besides this," says Mr. Ashpital, "the heavy duties imposed on the transport of stone by sea, and the high prices which all material bore during the war, threatened to reduce masonry to its lowest." The revival of Gothic architecture has renewed the use of freestone, and has taught our masons the art of working tracery, groined roofs, flying buttresses, and such use of stone as was supposed, scarce a century ago, to be one of the lost arts.

Eighteenth

And nineteenth centuries.

Besides this, the abolition of duties and the introduction of many facilities of transport by steam, both by land and water, has so reduced the price of stone, that in many places the use of cement is a false economy.

Further, the facility with which not only the upper classes but working men can visit other countries, has tended, whilst elevating the taste of employers, to improve the mental appreciation and manual skill of our artisans; and they have thus become qualified to execute the great monuments of skill which the present age has produced, and which will ever redound to the honour of our land.

The vast engineering and railway works—bridges, vaults, arches, and tunnels, the new Houses of Parliament, the lighthouses, exchanges, town-halls, churches, warehouses, &c.—which have of late years been executed in this country under the guidance of distinguished architects, have given such an impetus to the study and practice of constructive masonry, that a race of masons has been reared amongst us of higher and more varied skill than have perhaps ever existed in England, and even this standard is daily being improved by the efforts made for the promotion of the education of working men.

MASONRY.

LINEAR DRAWING BY MEANS OF INSTRUMENTS.

Walling.—The work of the mason in this department calls for the continual exercise of skill and judgment, for he has, not like the bricklayer to deal with blocks of a uniform size, but with heavy masses of all shapes and sizes, whilst the length, depth, and heights of the walls he is building are all fixed.

The best or highest sort of stone walling is the easiest to set, for in it all the stones are tooled or gauged to regular sizes, to range in courses and to suit the thickness of the wall to be built ; and the most difficult is really that which is deemed the commonest, being that in which rough blocks are used, the mason merely chipping them with his hammer or axe, and fitting them in the best way he can, so as to form a compact mass. This is called Rubble walling.

All stone is to a certain extent brittle, and therefore great tact is required in setting these irregularly-formed blocks, so that the ends may not be supported whilst the space between them is hollow ; or that the stone may not rest on one projecting part whilst the ends are unsupported. If long pieces are used, they must be propped up in every part, lest they should break across, and thus occasion the whole superstructure to give way. And thus, although the object of the mason should be to form as compact a mass as possible, still that is done with the greatest safety, when the strength is equalised ; and, therefore, he will act the most judiciously in breaking a very long stone into two or more short ones, and working them in that state ; for, by this means, he knows how to support or counteract the effects of the extra joint which he makes. Joints which may ensue after the wall may be finished would be irremediable.

The mason must bear in mind that whatever may be the quality of the stone to be used, the wall should consist of as much stone and as little mortar as possible. If the stone be inferior in durability and power in resisting the effect of the atmosphere to what the mortar will be when hard, no ulterior good will be gained, besides the certain fact that the mortar will yield until it has set hard, and thus the block resting on it will be, during the interval, constantly changing its place as others are placed upon it. And if the stone be (as it should) the more durable material, the more of it entering into the wall the better.

The stones, however, should never be allowed to actually touch each other, any more than in brickwork; for where this might be the case, the mortar, shrinking in drying, would throw the whole pressure on the most prominent part, and so cause unequal bearing.

Bricks are wetted before working, for if the surfaces be covered with dry dust the mortar will not adhere; and further, they would absorb rapidly all the water out of the mortar, instead of allowing it to set gradually. Stone, however, being of a less absorbent nature than brick, it is not so important that it should be wetted; nevertheless, it is better that it should be in at least a damp state when it is worked, the adhesion of the mortar being then more certain and complete.

What "Bond" is, and the necessity for it, has already been fully explained and illustrated in "Building Construction;" and bond is of no less importance in stone than in brick walling; only a few observations in special relation to rubble walling will, therefore, be added.

The joints, instead of being made to recur one over the other in alternate courses, as with bricks and hewn stones, should as carefully be made to lock, so as to give the strength of two or three courses or layers between a joint in one course, and one that may occur vertically over it in another. In bonding through a wall, or transversely, it is much better that many stones should reach two-thirds across, alternately from the opposite sides, than that there should be a few extending the whole way through, called "thorough stones." It is, in fact, much to be regretted that through a false economy walls are sometimes built of two thin scales, or faces, with thorough stones placed occasionally to tie them together, the core being made up of rubble and mortar. This mode of structure should be very carefully guarded against. There is no better test of a workman's skill and judgment in rubble walling than the building of a dry wall—that is, one without mortar—affords. Walls are frequently built with mortar, which would have fallen under their own weight without it before they reached the height of six feet, in consequence of their defective construction, thus showing that they are held together merely by the mortar, which is very seldom a sufficient bond.

Masons are very apt to set thin broad stones on their edges to show a good face. This should be in every case avoided. Stones should, as nearly as possible, be laid in the direction of their natural beds—that is, on the surface which was horizontal in the quarry. To understand this, the student must be informed that there are two kinds of stone, viz., igneous (from the Latin word *ignis*, fire), and aqueous (from the Latin word *aqua*, water). The following brief passage, quoted from our Manual of "Building Construction," will explain these terms :—

The Igneous are such as have been formed by the agency of fire, which has melted some of their constituents, and left others hard and bright. The whole of the mass, when hardened, becomes of the same structure throughout, and forms the various sorts of granite used in building.

The Aqueous are such as have been formed by the numerous rocky particles which have been carried along and deposited by water in past ages. This sediment having become hardened by time and heat, now constitutes most of the stones used in building, which are sometimes, from their origin, called "sedimentary." Now, the solid masses we know as stone have not been formed by the sediment which was deposited at one period, but ages may have elapsed between each formation ; thus the stone is deposited in layers, called strata (from the Latin word *stratum*, strewn or spread out), and this is the reason that such stone may be split into slabs or flakes with comparative ease, whilst granite would only chip into irregularly shaped masses.

This will at once explain to the student the importance of the rule, that all Ashlars (which will be spoken of presently) should be laid on their natural beds ; that is, they should be placed so that the strata of which they are formed should be horizontal, or nearly so, as they were in the quarry from which they were taken. The purpose will be clear to any reflective mind, for it will at once be understood that the thin slabs or strata of which the block is formed will be more liable to separate as the stones yield to time, the influence of the atmosphere, or pressure ; and thus flakes will separate vertically and drop off, leaving a portion of the stone above unsupported.

PLATE I.

Walling is broadly classified into **Rubble** work and **Ashlar** work.

Rubble walling is **uncoursed** and **coursed.**

Fig. 1 is a sketch of a piece of walling in uncoursed Rubble. In this it will be seen that the work is carried on with stones of various sizes, and without reference to the heights of the courses, in a manner somewhat similar to the Cyclopean walling already described, the spaces between the larger blocks being filled up with smaller ones.

For this work the mason merely uses a scabling-hammer to break off the roughest projections of the stones, the trowel to lay the mortar, and the plumb-rule to keep the general fall of the wall perpendicular. To make a good and sound wall in this manner therefore requires attention and intelligence, in order that the stones may be fitted well together, using as little mortar as possible, yet carefully filling the smallest crevice, not only externally, but throughout the body, and placing the stones so that they pass into the thickness of the wall, so as to bond it crosswise into a compact mass.

Fig. 2. Coursed Rubble is that in which each course is brought up carefully to the same height, the line and level being used. Although each course presents in itself a uniform horizontal line, the courses are not uniform in their height, nor need all the stones in the same course be equal either in length or height. In coursed rubble walling the stones are generally rough dressed by the workman before he begins to set them. He is careful to get parallel beds to them; that is, to get the upper and lower surfaces perfectly parallel. The best face—that is, the one which is to form part of the front of the wall—is brought up to a tolerably level surface, and the ends, too, are worked with some care, the axe being used instead of the scabling-hammer.

The angle-quoins in coursed rubble are worked very neatly and with great care; they serve, in fact, as gauge courses for the others. A very nice appearance is produced by the quoins being tooled to a smooth surface corresponding to the dressings of the windows and doorways; this style is very much used in church building. Coursed rubble is sometimes faced with Ashlar, with stucco or cement.

Fig. 3. Ashlar work, shown in this figure, is that method in which the external surface of the wall is built of gauged stones in equal courses, with tooled and closely-fitting joints, to give the wall a smooth and uniform appearance.

The stones are axed, tooled, or rubbed, as may be thought most in character with the structure, or the part of it to which it belongs. Ashlar stones, or "Ashlars," as they are commonly called, are made of various sizes, as the character of the building may require, or convenience demand. They, however, generally run from 28 to 30 inches in length, and 8 or 9 inches in thickness, and 12 inches in height. Some of the ashlar stones are used crosswise as bond-stones, otherwise, the facing having no connection with the rest of the thickness of the wall, would soon totter and fall.

Bond-stones are generally put in alternate courses, with the backing to the jambs of openings, such as windows, and oftener, if these do not recur within lengths of five or six feet.* The bond-stones should not fall in the same perpendicular, except when they are in the jambs of openings, but should be differently placed in the various courses, by which means the bond between the front and back of the wall is spread over the whole.

Ashlar is commonly set in fine mortar or in putty. It is generally recommended that the ashlars should not be cut so as to be regular oblong blocks, but that when they have made a close vertical joint in front they should slope backwards, so as to leave, after the joint is about an inch deep, a triangular opening between each two adjoining stones. The upper and lower surfaces or beds of the stone, although parallel, are narrower at the back than in the front, in order to tooth in with the backing. Such an expedient may exert a slightly beneficial influence under some circumstances, but the mode of construction is essentially faulty, and unless the backing be set in a quick-setting cement, or be so well packed as to resist the tendency to settle away from the backing, no means such as these will in any way improve it. An excellent German writer, in alluding to this subject, says: "The first condition of correct construction is that all the stones should be rectangular, so that the bearing may be distributed over the whole surface. The careful squaring of the stones from every side is, unfortunately, in these days much neglected; and in order to obtain close horizontal joints in the front, the upper and lower beds are slanted backwards, the face being supported in a vertical position by slips of wood or pieces of tile. The inevitable consequence of such work is, that the whole superincumbent weight is thrown on the edges of the stones, which thus chip off or split in every direction as the settlement goes on."

Although, however, both the upper and lower beds of an ashlar, as well as the vertical joints, should be at right angles to the face of the stone, and the face-bed and vertical joints at right angles to the beds, in an ashlar facing, where the stones run nearly of the same thickness, it is of some advantage, in respect of bond, that the back of the stone should be inclined to the face, and that all the backs thus inclined should run in the same direction, as this gives a small degree of lap in the setting of the next course; whereas, if the backs were parallel to the fronts, there could be no lap where the stones run of an even length in the thickness of the wall. It is of some advantage likewise to select stones so that a thinner and thicker one may follow each other alternately. The disposition of the stones in each course should follow in the same order as those in the course below, and every vertical joint should follow as nearly as possible in the middle of the stone below.

The objections to bond-timbers in brickwork have been alluded to in "Building Construction," and these apply with equal force to stone walls.

Hoop-iron bond is not only available in all kinds of stone walling, including the highly-wrought, close-jointed work, but it is invaluable, as it may be used both longitudinally as well as transversely, as it may in brickwork; whilst it compels the building mason to bring his work up to a true and fair bed as often as the bond is to be laid in it.

The student will scarcely require any directions in drawing Fig. 1. The base-line and the vertical edge will, of course, be drawn first, then the stones in all their irregularity. The description of the mode of building will then be the best guide in drawing the example. The sketch should be done very lightly in pencil, and a pen may be used for the purpose of inking.

In drawing Fig. 2, Coursed Rubble, having drawn the base-line and vertical edge, the lines for the courses are next to be sketched, not *ruled*, for it will be remembered that the stones are rough dressed, the angle-quoins are, however, to be worked with greater neatness. All further information will be obtained from the preceding description.

Ashlar work, shown in Fig. 3, must be carefully and accurately drawn, all the lines being ruled, and the widths of the stones measured. In drawing the whole elevation of a building, however, it is not usual to draw all the courses or single stones; a few lines freely but correctly drawn merely indicate the species of work employed. The method of using the various mathematical instruments, together with plain hints on linear drawing, have been given in "Projection" and "Building Construction," and, although we desire to make each volume of this series complete in itself, it is obvious that to repeat such elementary information in this volume would necessarily curtail the information we desire to give on higher branches, and as the two subjects referred to must be considered as the basis of the present study, the reader is urged to take them up either before entering upon or together with this; and as all practical art is based on geometry, the system on which it is intended to base our instruction should be worked as follows: Linear Drawing, Projection, Building Construction, and Drawing for Masons. By this method the student will learn: 1. The properties of various forms employed, their relation to each other, and the methods of constructing them in the readiest and most correct manner. 2. The manner of obtaining views of them as solids, instead of merely as plane surfaces; the shapes of sections in various directions, the development of their surfaces, &c. 3. The subject of construction as a whole, and the adaptation of materials; also the various kinds of drawings used by builders, and the method of executing them, and will thus be prepared to enter upon the branch specially his own with that interest which grows from systematic instruction. It has been the fault of our artisans to be content with merely the amount of knowledge they have obtained from each other, and to take interest only in that which related to their own immediate branch. This limited view of knowledge is at all times to be reprehended, but it is especially wrong in the trades relating to building, in which the artisans have to work so closely into each other's hands. Thus the work of the mason and the bricklayer meet, and both must work in concert with the carpenter, so as to arrange for his joists, girders, wall-plates, partitions, roof-trusses, lintels, templets, &c. The carpenter must arrange so that his work shall suit the plumber, whilst it must almost imperceptibly glide into that of the joiner, who must again understand the requirements of the glazier, locksmith, &c. &c. It will thus be seen that no man can be said to be truly efficient who only studies his own occupation up to a rigidly-drawn line; the necessity for men being mutually helpful and working harmoniously together is thus practically shown.

When Ashlar work is smoothed or rubbed so as to take out the marks of the tools used in working, it is called *Plane Ashlar.* When the surface is wrought in a regular manner, like parallel flutes and placed perpendicularly in the building, it is called *Tooled Ashlar,* but when the faces are worked with a broad tool, without care or regularity, the work is said to be *Random tooled,* and when wrought with a narrow tool it is called *chiselled,* or *boasted;* when the surface of the ashlars are cut with very narrow tools they are said to be *pointed.* When the stones project from the joints the ashlar is said to be *rusticated:* in this kind the faces may have either a smooth or broken surface.

PLATE II.

When walls are not entirely of masonry, in the ordinary course of economic building, stone is frequently used for copings, cornices, string and blocking courses, sills, landings, steps, stairs, hearthstones, chimney-pieces, &c.; several of these will be found illustrated further on, and we proceed to speak of Quoins.

Quoin-stones are gauged and wrought blocks with parallel beds and vertical faces, placed at the angles of buildings with the intention of adding to their strength and beauty; they are used either with brick or stone walls, and are, as a rule, made to project beyond that to which they are attached. The quoins are covered with the rest of the wall, if it be of stone, and are made to occupy the exact space of a limited number of bricks in a brick wall.

Rustic Quoins.—In these the edges are either bevilled, or the margins recessed in a plane parallel to the wall. The recesses, which are at the joints, have, therefore, three sides—one in the plane of the wall, or parallel to it, and the other two generally at right angles to this. Rustic quoins were much used in brick buildings at the end of the last and beginning of the present century.

Rustic work is a mode of building in imitation of simple nature, rather than allowing the work to have the appearance of having been carefully finished by art. In this style, the stones in the face, &c., of a building, instead of being smooth, are hatched or pricked with the point of an instrument.

The most coarse or common rustic work is that where the edges are simply cut about one-half or two-thirds of an inch round the margin, so as to be in the plane of the wall, or parallel to it; and the intermediate part is broken with the hammer, so that the protuberant parts may project generally about an inch beyond the margin.

The recesses of rustics either run with the horizontal joints only, the projections having, therefore, the appearance of boards placed at small intervals, or sometimes the recesses run with both the horizontal and vertical joints; and, therefore, when placed in this manner, they have the appearance of projecting tablets.

Rustic chamfered is that class of work in which the faces of the stones are bevilled at an angle of 135° with the surface of the wall, and as the joints are at right angles to the faces the margins will also be at 135° with the joints, so that when two rustics come together the bevilling, or chamfering, will form an internal right angle.

Rustic work frosted is that in which the margins are reduced to a plane parallel to the plane of the wall, and where the intermediate part has the effect of ice with an irregular surface in protuberant parts.

Rustic work vermiculated is that where the margins are reduced to a plane parallel to the plane of the wall, and where the intermediate part of the stone or general surface is so formed as to have the effect of being eaten by worms.

Fig. 1 is an illustration of angle-quoins with chamfered edges, each quoin occupying the height of four courses of brickwork. The student is advised to adopt a definite scale to work to. The elementary examples herein given, although generally correct as to proportions, are not worked to scale, in order that the student, instead of merely measuring and copying the lines, may absolutely *work* the subject. It will be remembered that the general size of bricks is a trifle less than 9 inches long, about 4¼ wide, and 2¾ thick. As there is, of course, some little space occupied by mortar, and for convenience of measuring, we here consider bricks 9 inches long, 4½ wide, and 2⅞ thick.

Having drawn the base-line and perpendicular, set off on the latter the heights of the quoins equal to four bricks, and draw horizontal lines; between each of these set off the heights of the separate courses of bricks. Now draw the vertical edges of the quoins, and also the double lines representing the chamfer, or bevil; the recesses at the outer edge and at the angles will be done by means of the set-square of 45°. The lines for the courses of the brickwork may now be drawn from the points in the perpendicular previously obtained. This plan is better than setting off the height of each course of brickwork from the bottom, in which plan the smallest error or inaccuracy is carried on and increased, whilst in the method here shown no error can extend beyond four courses.

The method of colouring drawings and the principles of mixing colours have been given in "Building Construction" (Technical series), and also in "Our Houses" (Primary series); to these the student is referred, the following brief hints being merely given in order that he may be at once able to tint his drawing, and in the hope that he will endeavour to acquire further information from the books quoted.

The colour generally used for brickwork in elevation is crimson lake mixed with burnt sienna, or Venetian red. Brickwork in plan is coloured with crimson lake. It has, however, recently become fashionable to colour plans in full Indian ink. Stone generally should be tinted with yellow ochre or pale sepia, granite with pale Indian ink, clay or earth with burnt umber, and concrete works with sepia with darker markings.

In order that colour should flow easily, and cover a surface evenly, it is necessary that it should be thin. It is always easy to wash over it again if it should not be found dark enough, but it is very difficult to wash off the colour if it should be too dark.

When the colour has been laid on, do not touch it again whilst wet. If it should require retouching, let this be done when it has dried, as you will generally make it worse by stirring about in the wet colour, and will be likely to rub up the surface of the paper.

Use a large brush in preference to a smaller one wherever you can, as by this means you will be more likely to succeed in getting a flat wash, whilst a small brush might make the tint lie in streaks. You must, however, be very careful not to pass over the outlines when using a large brush ; the brush should, therefore, be held as uprightly as possible.

It is important in architectural drawing that the draughtsman should be able to lay a flat tint, and to accomplish this some practice is required. In order to obtain which you are recommended to draw figures of various sizes, commencing by colouring the smallest, and gradually advancing to the largest. Use a full brush of colour, and spread it as rapidly as you can, so that one part may not dry before you have coloured the whole surface.

In relation to the mixture of brick with stone ashlar in building, Sir Charles Pasley says that the stone should bear a definite proportion to the thickness of the brickwork in the wall, and mentions the British Museum, in which the stone is from 8 or 9 to 13 or 14 inches thick, in order to correspond with 1 and 1½ brick.

In stone pilasters, projecting from the face of a wall having a stone front, the courses are usually equal to two of the other courses in height, or even more, it being the custom to make such pilasters of much larger slabs than the rest of the wall.

Door and window jambs are also generally made in much higher courses, or even sometimes in one piece, which is by no means unusual.

As the joints in brickwork being more numerous, are more liable to be compressed, and consequently that portion of the brickwork is liable to settle more than the stone front of the wall, it is prudent never to hurry the brickwork, but to carry it regularly all round the building by portions of a small number of courses at a time.

Fig. 2 in this plate represents a section of a wall having a stone front backed with bricks. In this example the stones are of the height of five courses of brickwork, and 8 or 9 inches thick, with some of 12 or 13 inches thick intermixed with them, and "thorough" or bond-stones at intervals, the total thickness of the wall is equal to three bricks.

The method of drawing this example is precisely similar to the last, no further directions are therefore necessary.

STONE ARCHES AND VAULTS.

PLATE III.

AN arch in masonry is a part of a building suspended over a given space, supported only at the extremities and concave towards the plan. The general history and principles of construction of arches have been given in "Building Construction;" only such portions of what has there been said are repeated as are necessary for the further investigation of the subject; and, for the rest, the student is referred to the volume alluded to.

The supports of an arch are called the *spring walls.*

The whole of the under surface of the arch opposite to the plan is called the *Intrados*, and the upper side is termed the *Extrados.*

The boundary line or lines of the intrados, or those common to the supports and the intrados, are called *springing lines* of an arch.

A line extending from any point in the springing line on the one side of the arch, to the springing line on the opposite side, is called the *chord* or *span* of the arch.

If a vertical plane be supposed to be contained by the span and the intrados of the arch, it is called the *section of the hollow* of the arch.

The vertical line drawn on the section from the middle of the spanning line to the intrados, is called the *height* of the arch, as also the middle line of the arch, and the part of the arch at the upper extremity of this line is called the *crown* of the arch.

The curved parts on the top of the section between the crown and either extremity of the spanning line are called the *haunches* or flanks of the arch.

Arches are variously named, according to the geometrical figure, by means of which they are formed, as

semicircular, *elliptical*, *cycloidal*, *catenarian*, *parabolical*, &c.; these, as well as the *horseshoe*, *stilted*, *composite*, and *pointed*, together with the method of constructing them, have been given in "Building Construction."

When the extremities of an arch rise from supports at unequal heights, it is called **Rampant.**

When the upper line or side of an arch is parallel to the under line or side, it is called an **extradossed** or **concentric** arch. Fig. 1.

When the outer side of the curve is drawn from another centre, it is called an **Eccentric** extrados. Fig. 2.

The term *Arch* is frequently confounded with *Vault;* but the distinction we shall adopt here is based on the degree of depth, an arch being a structure of no very great depth from one side to the other, whilst a vault may be unlimited. Thus we say an "*arch in a wall;*" but "a *vaulted apartment*" or cellar, so that a vault is an extended arch. Practically every vault is an arch—but every arch is not a vault.

A Vault is **cylindric** when its form is that of a cylinder never greater than the half when the axis is in the same plane with the springing of the arch. It is also termed **barrel** or **wagon-headed.**

A Vault in *full centre*, is one which is formed of the surface of a semicylinder.

A Vault is said to be *surmounted*, or *surhaussé*, when it is formed by the portion of any curve where the height is greater than half the span.

A vault is termed *Surbase* when the height at the crown is less than half the width of the springing.

A **Rampant** vault is one the springing of which is not parallel to the horizon, as in many staircases descending into cellars.

Conic vaults are, as their name implies, of the form of a cone. They may be of three kinds, according to the disposition of the axis—viz., parallel, perpendicular, or oblique to the horizon.

Spherical vaults are usually called *Domes*. All domes are, however, not spherical, since they may spring from a polygonal, circular, or elliptic plan, presenting a convex surface on the outside, and a concavity within, so that every horizontal section may be of a similar but different-sized figure, and have a common vertical axis.

The word *Dome* is applied to the external part, and *Cupola* to the inner part.

It is believed that the term is derived from the Latin word *domus*, a house. The Germans call it *dom*, and the Italians *duomo*, and apply the name to the principal church of a city, although the building may not have any dome.

An **Annular vault** is one of which the plan is contained between two concentric circles, its generating section may either be that of a pointed arch or of a semicircle, or, indeed, of any other curve.

A **Simple vault** is one which is constructed of the surface of some regular solid, around one axis or centre.

A **Compound vault** is one which is made up of more than one surface of the same solid or of two different solids, such as would be formed by two cylinders, or spheres penetrating each other.

Cylindro-cylindric vaults are such as are formed of the surfaces of two unequal cylinders.

Groined vaults rise in their surfaces to the same height as two equal cylinders, or a cylinder with a cylindroid. Several of these arches or vaults will form the subjects of future lessons. We, therefore, now proceed to give the method of drawing the examples.

Fig. 1 is the elevation of a concentric semicircular arch. The student is reminded that in this all the joints must be radii of the circle of which the arch is one-half, and that the separate stones of which the arch is built are

PLATE III.

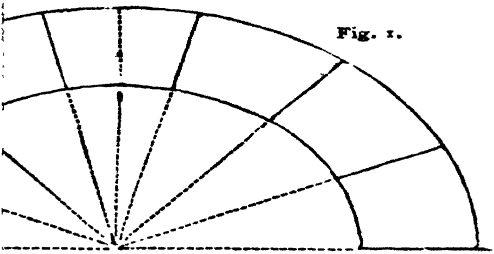


Fig. 1.

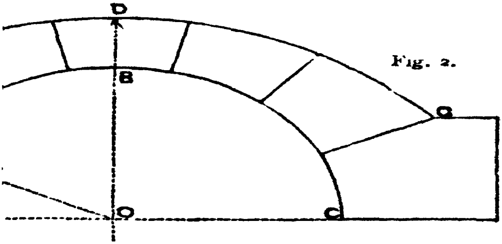


Fig. 2.

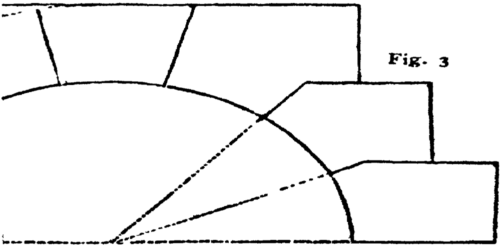


Fig. 3

called *voussoirs*, the middle one being the *keystone*, and the two lowest—that is, those resting immediately on the abutments or piers—being termed *springers*.

Fig. 2. This example shows a section of a semicircular vault with an eccentric extrados. This system is much more solid than that shown in Fig. 1, whilst the depth at the crown may be the same.

To draw the eccentric arch, the intrados A B C having been described, and the height of the extrados having been fixed at D, set off from B, two-thirds, three-fourths, or even the whole length, A C, viz., to E, then, with radius E D, describe the extrados F D G. The divisions of the voussoirs must be set off on the intrados, the joints converging to the centre O.

Fig. 3 shows the manner of terminating the arch by horizontal and vertical lines. These are drawn from the points where the radii cut the extrados. When it is desired that the horizontal lines should coincide with the courses of stone, the horizontal joints are continued until they cut the radii; this is shown in the right side of the example. This method is not as good as that shown on the left side, where the pressure is borne uniformly by the whole joint; for it will be seen that an interior angle has to be cut in the under surface, into which an external angle cut in the stone beneath must fit; but if this angle is not cut with the utmost accuracy, the construction would be compromised by the transverse cracking of the stones when under pressure.

PLATE IV.

Fig. 1 in this plate is an arch formed by the segment of a circle. This method is frequently employed in the construction of bridges. It will be seen that the intrados having been divided into the required number of parts, the joints for the voussoirs, which are radii of the arc, are carried up, and are intersected in groups by the horizontal courses of the stonework.

Fig. 2 shows a semi-elliptical arch, the curve of which may be constructed in any of the various methods shown in "Linear Drawing." To find the direction of the joints, which must be perpendicular to the curve, divide the intrados into the required number of equal parts, and from the foci F and F draw lines to each of these points, as shown at A; bisect the angle thus formed, and the bisector A C will be one of the joints required.

It will be seen that this is an illustration of a surbased vault, the height at the crown being less than half the width of the springing.

Fig. 3. This is a rampant arch. To draw the intrados of this, the height of the imposts A and B being given, draw the line A B, joining the imposts, and bisect it in C. At C draw a vertical line, and make C D equal to C B. From D draw a line at right angles to A B, intersecting horizontal lines drawn at A and B in E and F, which will be the centres required.

Draw the arc D B with the radius E D, and the arc D A with the radius F D.

Divide the intrados into the required number of equal parts, and the joints will be radii of the arc in which they are contained.

PLATE V.

Platbands.—A platband is any flat square moulding whose height much exceeds its projecture. Such are the faces, or "fasciæ," of an architrave, and the platbands of the modillions of a cornice.

The platband of a window or door is used for the lintel, where that is made square or not much arched. These platbands are usually crossed with bands of iron when they have a great bearing; but it is much better to ease

PLATE IV.

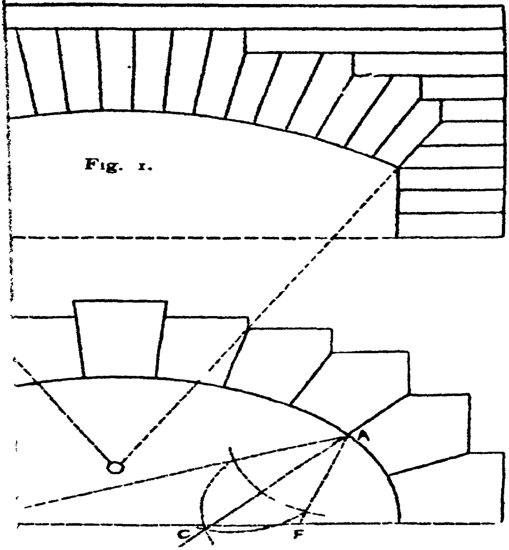
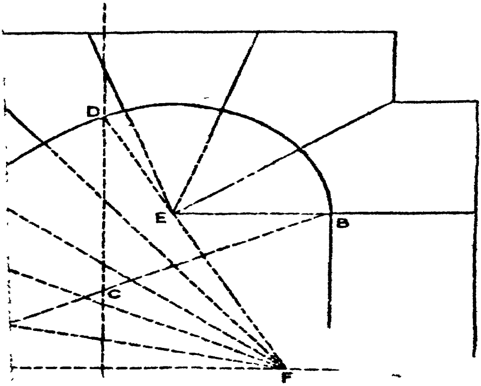


Fig. 1.



hem by building discharging arches over them. The ses of both lintels and discharging arches have been xplained in "Building Construction," to which volume he student is referred.

Fig. 1. The whole platband of a window or door, which s simply a straight arch, must form a trapezium, A B C D, f which the upper line, or extrados, C D is, of course, the ongest side; and each of the stones should be of the rapezium or wedge-like form, so that neither of them may lip between the others.

To accomplish this, divide the intrados A B into an neven number of equal parts. Construct on A B the quilateral triangle (which form is usually adopted) A B O.)raw lines from O through the points in the intrados, utting the extrados. These lines will give the keystone nd the voussoirs.

Fig. 2. In this figure another method is shown which naterially adds to the strength of the arch. To construct his form, divide the intrados as before into an uneven umber of equal parts; produce the sides of the piers eyond A and B, and draw the line C D. From the points f division draw perpendiculars, as K, and from D K, c., draw the joints. It will be observed that the pres-ure is thus brought to be as much as possible downward nstead of outward, since the main bearing of the plat-and is on the horizontal top of the pier E F.

Fig. 3 is another example for drawing a similar subject, which increased strength is given by increasing the epth of the voussoirs as they approach the keystone. he method of drawing this subject will be understood om the previous examples.

FREEHAND DRAWING FOR STONEMASONS.

IN a previous volume of this series we have said: "It is advisable that the student should be informed that *all* the drawing which is necessary for the artisan cannot be done with *rules* and *compasses*, but that some portion of the work must be done by freehand."

It is important that a workman should be able, with his piece of chalk or pencil, to sketch rapidly by hand the form of any object he is required to make; or that visiting any exhibition or foreign country, he should be able to bring away with him drawings, however roughly done, of any tool, appliance, or useful or ornamental article which may have attracted his attention.

Again, as the examples contained in this or any other work of a similar character advance, it will be seen that curved lines are of constant occurrence, and although some of them which may be composed of arcs of circles may be done with compasses, and others may be inked by means of the French curve, there will still be found many which can only be done by what has properly been called "freehand," and there will occur little pieces of curved lines continuous with straight ones which can always be more neatly joined by hand than by instruments, or which, after a certain amount of practice, the draughtsman will be able to execute with his pen or pencil in less time than it would take him to find the centres. But this is not all. The study and practice of freehand drawing gives accuracy to the eye, and refines the perceptive faculties; it enables a man to raise his ideas beyond mere straight lines, to cultivate his taste, and in many ways to add beauty to utility.

These remarks apply with equal force to stonemasons.

ATE V.

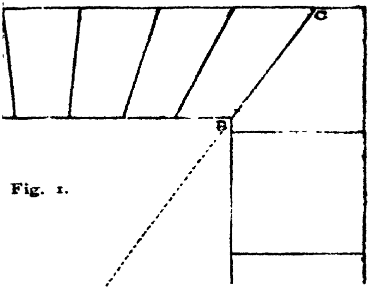


Fig. 1.

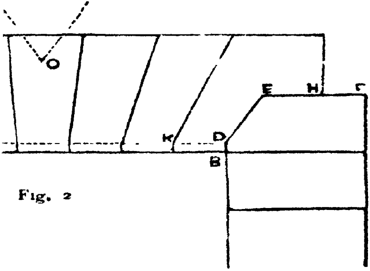


Fig. 2

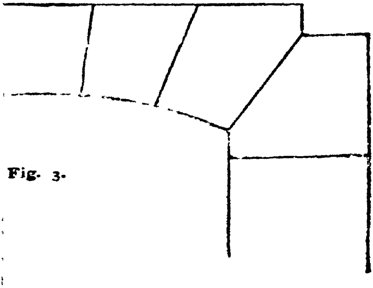


Fig. 3.

Surely it cannot be right for a man to make up his mind that because a templet cut out of zinc, &c., is given him, his sole work in life is to place it against the end of the block of stone, scribe round it, and chip away until the block is the same shape all along—to work a plain surface to a block, to work accurate joints, or to set the stones according to the working drawings ; although all such work, and very much more, is not only important, but absolutely indispensable to the mason. But the workman must remember that he is not a mere machine—that knowledge and intelligence are required in every branch, and that the more accurately the eye is educated to appreciate carved forms, the more readily will the hands execute the work. The manual skill of our stonemasons is unquestioned ; the noble buildings daily rising up around us testify to this, and it is to urge on the British workman the necessity for increased mental culture and refinement in skilled labour that these lines are written. A mason may not have to design a moulding, a drawing or templet of which is furnished him by the architect or foreman of the works, but it cannot be doubted that he will execute it more readily and with greater accuracy if he understands the geometrical construction or appreciates the relation of one curve to another ; and his knowledge will enable him to work with interest and intelligence, instead of by mere rule of thumb or, as it were, instinct. Besides this, the line which separates some branches of masonry from stone-carving is difficult to define—the one grows out of the other ; and although every man should determine to do his best in his particular vocation, it is still his bounden duty to use every endeavour to raise himself, and this can only be done by earnest study and perseverance. To the young artisan this is particularly addressed, and he is urged to follow up the elementary course of studies here laid down ; thus, as he advances in years, he will advance in knowledge, and instead of going to his work as a mere day-labourer, he will throw his spirit into his occupation and it will become to him a labour of love.

The schools of art which, thanks to the Government Department of Science and Art, are now widely spread throughout the country, afford means of instruction of the highest character. The admirably-arranged courses of studies adapted for each branch of practical art, the collections of casts, libraries, and, above all, the excellent teaching to be obtained, all offer opportunities not previously open to working men, and of which they are urged to avail themselves.

PLATE VI.

Fig. 1. In order to economise space, this figure may be used as three separate studies, of which the easiest may be taken first. Draw the vertical line A B, and the oblique line C D, giving the general inclination and extent of the curve to be drawn.

Now set off between C and D the points E and F, and draw lines at right angles to C D. Make these equal to E H and F G, and trace the curve through D, G, and H to C.

It must be pointed out that the curve should not spring suddenly or abruptly out of the perpendicular line, as shown in Fig. 2, but must merge so gradually into it that it shall become at last a portion of the straight line. This will require some little practice to accomplish, but as it is one of the most important points in ornamental drawing, attention is at once called to it.

The two lower curves on the same side may now be drawn, each a little larger than the one preceding it. The straight lines used in the first curve are, however, merely intended as leading-strings, and, therefore, as soon as the smallest amount of power has been attained, they should be rejected and the curve drawn without such extraneous aid.

Proceeding now to a further stage of the study, draw another vertical line, and draw the curves on the left side, which in the present study will be found rather more difficult to draw than those on the other; the hand should be placed rather higher up on the paper, and the pencil should be held rather longer than in the previous practice. It may here be well to mention that in freehand drawing generally the pencil should be held as long, and the eye should be kept as far from the paper, as may be convenient. By these means freedom of hand and a just view of the form is obtained.

In sketching, these curves should be at first very lightly traced. They should not be made up of repeated scratches touching or crossing over each other, as in Fig. 3, but of small pieces, which in themselves form portions of the line to be drawn (Fig. 4).

The work having proceeded thus far, is called the rough sketch; but the term *rough* must not be taken to mean *coarse*—it merely implies that the first delineation of the required form is more broad than accurate—that it gives the general form rather than the detail. This will, however, be gradually improved, and, therefore, it is necessary that the sketch should be done as lightly as possible.

The sketch is now to be converted into a drawing. To do this, pass your india-rubber lightly over the pencil lines, so as to remove as much lead as possible without entirely erasing the form. In using india-rubber, it is better to rub in the direction of the lines than across them; and when there is much lead upon the paper, it is better that the friction should be rapid and light, rather than slow and heavy. The rubbing should not be backward and forward, by which the lead rubbed off the lines by the one stroke is rubbed into the paper by the next, but the action should be like planing or filing—namely, in one direction, the rubber being raised in the backward motion.

The paper should at this stage present a perfectly clean appearance, with a very clear but slight trace of the form.

Now, with a very fine, cleanly-cut point to your pencil, trace over the outline, avoiding all raggedness and endeavouring to get each line of the same thickness throughout. This process is called "lining-in."

Having thus practised the method of drawing simple curves inclined towards the right and left sides, the example may be copied as presented in the plate, the great object to be kept in view being that the curves must *balance* each other—that is, that the one on the right must be the exact counterpart of that on the left.

Draw the vertical line A B, and the horizontal D H crossing it; set off on this the distance to which the curves are to extend—viz., D H—and on the perpendicular mark the point C. Now, whenever lines are to be balanced, the one on the left side should be the first drawn, for it will be clear that if the curve on the right side were sketched first, the hand would cover it whilst drawing the other, and this would add much to the difficulty of balancing the different parts. Horizontal lines, in order to regulate the heights of the curves, may be used in elementary practice; but after a while a few touches rapidly sketched across will be found sufficient, and all squaring of freehand forms should be discarded.

Fig. 5. The lines which form the subject of this stud differ from the previous ones, in being each composed o two distinct curves.

It will be seen that the curve starting from *a*, pro ceeds as far as *b*, and then turns in another directior This peculiar bend requires much care, for the exact pos tion of the point at which the change takes place materially alters the form. In order to afford some guide to the student, the line *a c* is drawn, and the change of direction in the curve takes place at the point *b* of this line.

As in the last subject, it is intended that the single curves should be practised before attempting to balance them.

Draw a vertical line, and a horizontal at its extremity; draw *a c* at the required inclination, and mark on it the point *b*.

Now divide *a b* and *b c* into equal parts, and draw the lines *d e* and *f g* at right angles to *a c*. Make *c e* and *d f* equal to the depth of the curve; then, commencing at *a*, trace the curve through *e*, *b*, *f*, to *c*.

Care must be taken that there be not a sudden bend at the juncture, but that the curves may flow gracefully and imperceptibly into each other.

Assuming, then, that the student has had some practice in drawing the separate curves as they appear on each side of the vertical line, he may then proceed to draw the complete subject, aided at first by the guide lines, and subsequently rejecting them.

In the two lower curves the practice is advanced to a curve growing out of another. This is another important point in ornamental drawing, and has been referred to in relation to Fig. 2. It will be seen that, although the branch *i* springs from *h*, it does not project suddenly from the curve *g i*, but merges gracefully out of it; so that if the part of the curve *g h* were removed, the curve *j h i* would still be complete, and if the branch *h i* were taken away, the remaining curve *g k i* would not be interrupted.

Fig. 6. In this study, the practice afforded in both the previous lessons is applied. The simple and compound curves being employed, and the branch carried round so

as to form a simple scroll. The student is urged to copy the whole of the figures given in this plate several times, as the practice they afford is of the utmost importance to him.

MASONRY.

LINEAR DRAWING BY MEANS OF INSTRUMENTS—(*continued*).

Mouldings.—When the face or edge of any work is wrought into long regular channels or projections, the sections of which form various curves or rounds, hollows, ogees, &c., it is said to be *moulded*, and each separate member is called a *moulding*.

Mouldings are divided into Grecian, Roman, and Gothic.

Grecian mouldings are formed of some of the curves known as conic sections, such as the ellipse or hyperbola, and sometimes even of a straight line in the form of a chamfer.

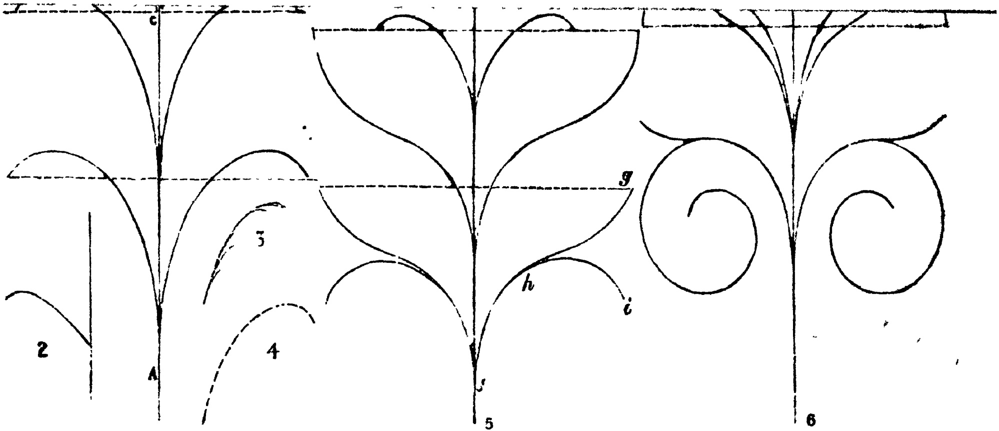
Roman mouldings have their sections composed of arcs of circles, and thus they are found the easier for elementary practice in drawing.

PLATE VII.

Fig. 1. This is the simplest of all curved mouldings; it is called the **Torus**. It is merely a semicircle described upon the vertical diameter; it is used in the bases of columns.

To draw the Torus, let A B be the height of the member. Bisect A B in C, and with the radius C A describe the semicircle.

The Torus, when very small, is called an **Astragal** (Fig. 2), which projects; but it is termed a **Bead** (Fig. 3)


c
g
3
h
i
2
A
4
5
6

when it does not stand out beyond the surface. Several beadings placed together are termed *reedings.*

A **Fillet** is a small flat face (Fig. 4) placed between mouldings to divide them.

A fillet is, in the bases of columns (as shown in Fig. 1), and at the top (as in Fig. 5), joined to a face or to the column itself by a small quarter-round hollow, called an Apophyge. The word is originally Greek, and signifies *flight.* English architects and builders generally term it the "scape" or "spring" of a column.

The method of drawing these is so very simple that it is not deemed necessary to do more than refer the student to the examples.

The **Ovolo** (the name of which is derived from the Latin word *ovum*, an egg) is a projecting mould, which, in the Greek styles, is a portion of a conic section, but which in the Roman is merely a portion of a circle—generally a quadrant—in which case it is called a "quarter-round" (Fig. 6).

To describe a Roman Ovolo (Fig. 6), or quarter-round, let A be the upper extremity and B the lower. At B erect a perpendicular cutting a horizontal drawn from A in C; then, with radius C, describe the quadrant or quarter-round.

To describe a Grecian Ovolo (Fig. 7), two tangents being given, as also their points of contact. Let A E and E B be the tangents; A and B the points of contact. Complete the parallel from B, E, A, *d.*

Produce B *d* to C, and make *d* C equal to *d* B; divide E A and A *d* each into the same number of equal parts. Through the points of division in A E draw lines to B, and from C draw lines through the points of division in A *d.* These lines intersecting those previously drawn, will give the required curve which is a portion of an ellipse; the upper part A Q is a continuation of the same curve.

PLATE VIII.

Fig. 1. This moulding is called a **Cavetto**, the name of which is derived from the Latin word *cavus*, a hollow. It is a concave moulding, the curvature of whose section does not exceed the quarter of a circle. Its projection may be equal to its height, and should never be less than two-thirds of it. The cavetto, which is the reverse of the ovolo, is sometimes used in the bed and crowning mouldings of cornices.

The method of drawing the cavetto will not need any explanation.

Fig. 2. The **Scotia** is a recessed moulding of an elliptical section, when properly constructed. It is, however, for general purposes formed by the junction of two circular arcs of different radii. This moulding has an effect just the opposite to that of the ovolo or torus, and is sometimes composed, like the latter, of a semicircle only.

To draw the Scotia, divide the height of the moulding into three equal parts. From any point, as *a*, on the line drawn at two-thirds from the bottom, draw the quadrant *a b*; from *a* on the same line set off *a c*; from *c*, with radius *c b*, describe the quadrant *c b d*, which will complete the moulding.

Fig. 3 is a section of the frequently used moulding, called the **Cyma Recta**. The exact form of this moulding is, to a certain extent, a matter of taste, since the curve may be drawn more or less full, the variation being caused by the radius with which the arcs are struck. The curve most generally used is given here, and the following is the method of describing it.

Let *a* and *b* be the points to be united by the moulding. Draw the line *a b*, and bisect it in *c*; from *c* and *a*, with radius *a c*, describe arcs cutting each other in *d*; and

LATE VII.

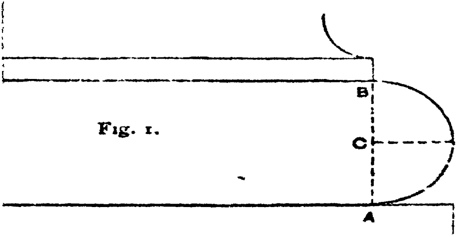
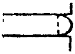


Fig. 1.



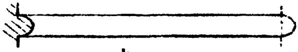


Fig. 2.

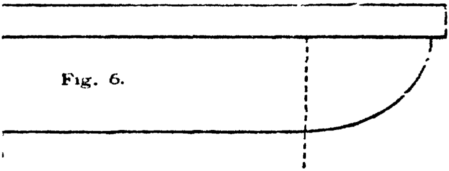
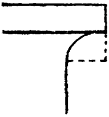


Fig. 6.



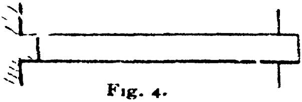
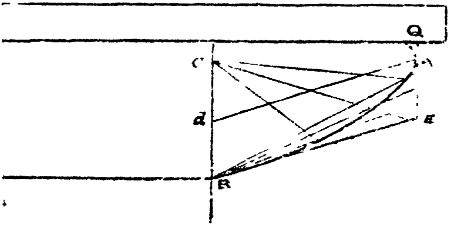


Fig. 4.



from *c* and *b* describe arcs cutting each other in *e*; from *d* and *e*, with the same radius, describe arcs meeting in *i*, which will give the form of the moulding. If it be required that the lower portion of the curve should be more full than the upper, divide the line connecting the two extremities of the section into three equal parts, construct an equilateral triangle on the upper third, and another on the *two* lower portions, then the apices (plural of *apex*, the upper point) of the triangles will be the centres from which the arcs are to be struck. This, and several other methods of describing various mouldings, are described and illustrated in another volume of this series.*

Fig. 4 is the **Cyma Reversa.** In this moulding the curve bulges outward at its *upper* part, and it is exactly the reverse of the Cyma recta. As in the former figure, the exact form is regulated by the taste of the designer. In this, and all the curves composed of combined arcs, the greatest care is necessary, so that the one may glide smoothly into the other without showing any break or thickening in the joining, which materially injures the effect. This has already been referred to, and it will be at once seen how the taste, when cultivated by the study of ornamental drawing, will aid in the appreciation of these forms, which add so much to the beauty and gracefulness of a building.

OF THE METHOD OF DESCRIBING A RAKING MOULDING.

PLATE IX.

RAKING is a term applied to such members of a building as slope or lie inclined to the horizon. Raking mouldings frequently occur in masonry. The following example is therefore given in order to explain the method of forming them to mitre in a proper manner:—

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* "Drawing for Carpenters and Joiners," Figs 178 to 198. The mouldings belonging to Gothic architecture are also fully illustrated in "Gothic Stonework."

The subject of this lesson is a design for a cornice, having part of the moulding level and part inclined, as occurs in the pediment of a building. In this drawing *a e* is the moulding at the angle of the break or projection of the pediment. With this moulding given, we have to find the right section of the ogee in the pediment.

Let *a f* and *e e′* be the two parallel lines which terminate the breadth of the raking, or inclined moulding; and let *a k* and *e l* be the parallel lines terminating the breadth of the moulding which is level.

At a convenient place draw *p t* parallel to the edge *a k* of the horizontal portion of the moulding. Between *a* and *e* place any number of points, as *b*, *c*, *d*, and draw *b g*, *c h* and *d i*, parallel to *a f* and *e e′*.

At *a*, *b*, *c*, *d*, *e* draw perpendiculars to *e l*, cutting the line *p t* in *q*, *r*, *s*.

Now, at any convenient distance, draw a line parallel to *a f*, and transfer to it the distances *t*, *s*, *r*, *q*, *p*, viz., *t′*, *s′*, *r′*, *q′*, *p′*.

From each of these points draw lines at right angles to *a f* and *e e′*, cutting *a f*, *b g*, *c h*, *d i*, and *e e′* in A, B, C, D, E. The curve traced through A, B, C, D, and E will be the right section of the raking moulding.

To find the section through the mitre of the two inclined sides where they meet at the top of the pediment, draw *t″ p″* perpendicular to *t″ e′* and equal to *t p*. Transfer the distances *t*, *s*, *r*, *q*, *p* to the space between *t″* and *p″*, and draw perpendiculars from *s″*, *r″*, *q″*, *p″*.

From *f*, *g*, *h*, *i* draw lines at right angles to *f e*, and through the points where these intersect the perpendiculars, viz., *a′*, *b′*, *c′*, *d′*, and *e′*, draw the curve, which will be the common section of the mouldings at their junction at the apex of the pediment.

PLATE VIII.

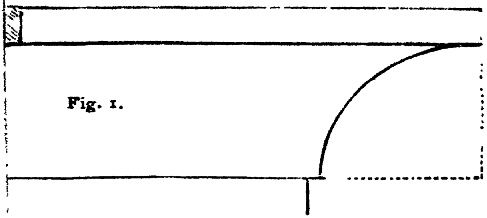


Fig. 1.

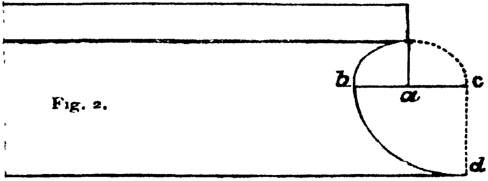


Fig. 2.

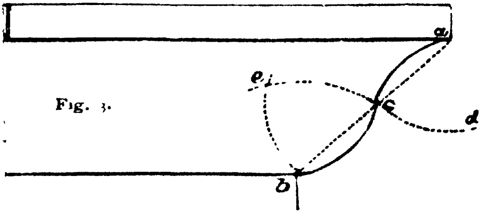


Fig. 3.

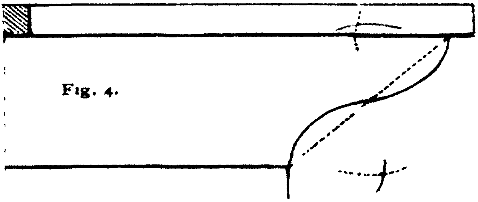
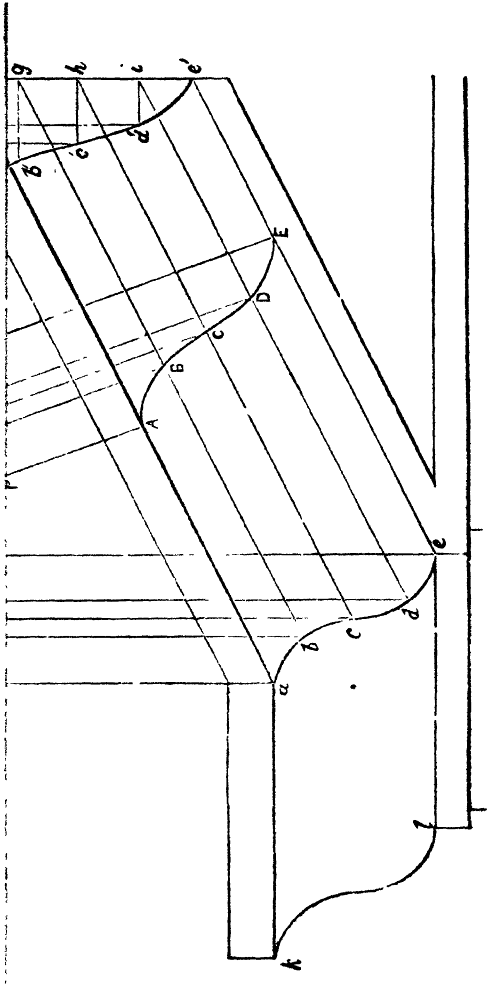


Fig. 4.


g
h
i
e'
b'
c'
d'
E
D
C
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P
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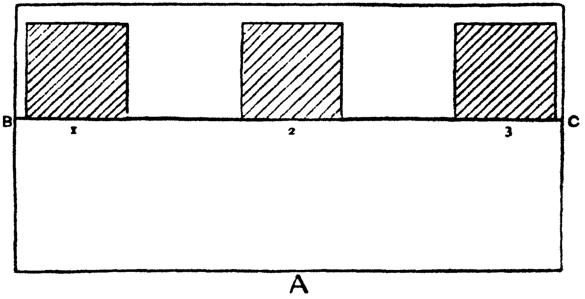
k

DRAWING FROM SOLID OBJECTS.

It has already been said that it is important that the student should obtain some knowledge of drawing without the aid of instruments, since he will thus acquire the means of expressing his ideas in a rapid and clear manner. This must not, however, be understood to apply to freehand ornamental drawing only, or to the representation of forms which are generally considered as "flat;" that is, presenting to the eye of the spectator little or no thickness. To the mason in particular, a knowledge of the method of drawing from solid objects is of the utmost importance, and it is therefore intended to give a few simple lessons on this branch of the subject, and to adapt them as nearly as possible to the particular branch of industry treated of in this manual.



Let the rectangle here drawn represent the top of a table, at which the student is supposed to be sitting. His position is supposed to be at A.

Let us further suppose that on the table are placed three cubes, or solid squares; the plans (or pieces of ground on which they stand) being represented by the squares 1, 2, 3.

(It will, of course, be clearly understood that the blocks employed in this lesson need not necessarily be cubes, but may be any rectangular solids.)

PLATE X.

Now, let us attempt, guided by the figures in Plate X., to draw these objects. Since the student is supposed to be sitting with his chest parallel to the edge of the table, to which the faces of the cubes are also parallel, the front of each of the objects will retain its original shape, viz., a square. We will first draw square No. 1.

Now, it will be clear to you that if the object were placed lower than the level of your eye, you would see its upper surface, as you see the top of a block of stone lying on the ground, and that if it were placed higher than your eye, you would see its lower surface, as you see the bottom of a block which is being hoisted up by a crane.

This, then, is the first point to be settled by asking yourself, "Is my eye higher or lower than the object?" You will, of course, be able instantly to decide this. Next comes the thought, "As my eye *is* higher than the block, about *how much* higher is it?" This, too, you will soon be able to decide by trying how many times its own height you could raise the block before you lose sight of the top.

When you have decided on the height of your eye in relation to the object, draw a horizontal line (H L) across the paper, which shall have the same height in proportion to the square you have drawn, as the real height of your eye has to the model; that is, supposing you see that your eye is doubly as high as the block, draw the line H L as high again as the square you have drawn to represent the front. This will call for an exercise of judgment, but a little practice will soon enable you to fix your height with tolerable exactness.

Now, this line H L is called the horizontal line, and so we come to the following definition :—

The Horizontal Line represents the height of the eye of the spectator.

If a sheet of glass were placed upright between your eye and the object, so that the edge on which it stands rested on the line B C in the figure in page 55, and the line H L were drawn upon it, then, when you looked straight forward, the point on the horizontal line immediately opposite your eye would be called the point of sight; so that we have here a second definition—

The Point of Sight, or Centre of Vision, is the point in the picture which is immediately opposite to the eye of the spectator.

Looking straight forward then, is your eye on the left or right side of the object? Well, in this case it is clearly on the *right;* and how much it is so you must judge in the same manner as you did in the matter of the height —viz., by comparing your distance with the size of the object, and then marking the point of sight, or centre of the picture C, on the horizontal line.

The next rule is—

All lines which in the object are at right angles to the picture-plane must be drawn to the point of sight.

Now, referring to the figure in page 55, you will see that, supposing the sheet of glass which represents the picture-plane to stand on the line B C, then the lines forming the sides of the squares (for you must remember that the squares are the *plans* of the cubes) are at right angles to the line B C, and all such would therefore be drawn to the point of sight. Therefore, from the three angles of the square, draw lines converging to the point of sight, as shown in Fig. 1.

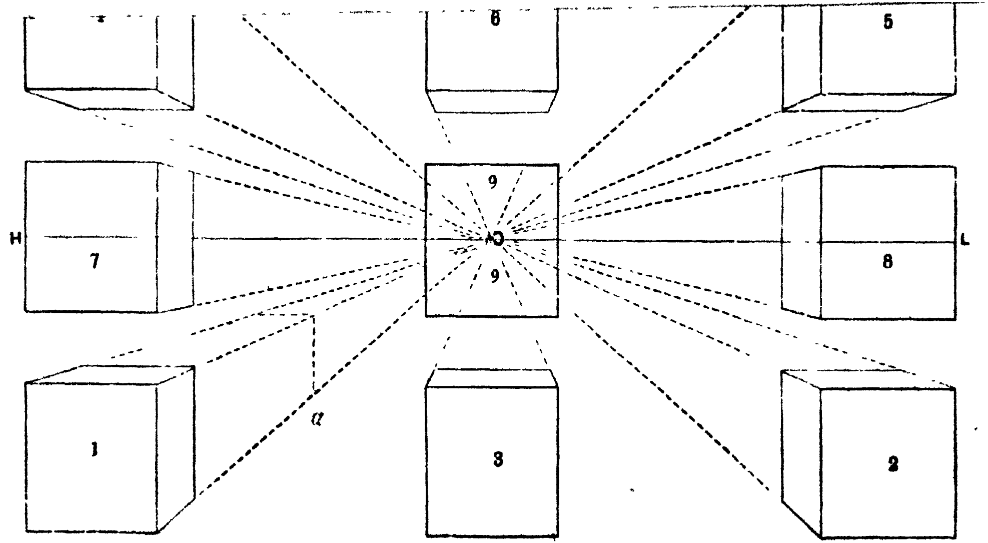
Portions of these lines will form the edges of the cube, and you must terminate them by a horizontal line for the distant edge of the top, and another for the distant edge of the right side. It is not intended here to give you any definite rule for finding this width. This would carry us beyond the limits of this volume; you are therefore referred for further instruction in this branch of the subject to that treating specially of practical perspective. At this stage you must use your judgment, and you will find that with very little practice and observation you will be able to form a very just notion of relative distances; for you will see that if you were to place the lines just drawn far up between the convergent lines (as at *a*), your sketch would look like a balk of timber or long block of stone; whilst if you placed them very near the square, you would represent a mere slab.

Fig. 2 is a similar cube placed on the right side, and therefore the view you obtain of it is precisely the opposite to the previous one; and the method of drawing it will be precisely the same.

Fig. 3 is placed immediately in front of you, and thus you see neither the left nor right side; but its height being exactly the same as the others, the top would be visible. Having, then, drawn lines from the two upper angles of the square, draw lines to the point of sight, and then only one horizontal, representing the distant edge of the top, will be required to complete the view.

Figs. 4, 5, and 6 represent a similar set of three cubes, placed above the level of the eye of the spectator, and therefore the convergent lines tend downward instead of upward, and thus the underneath surfaces of the cubes become visible.

Figs. 7 and 8 represent the objects when placed exactly on a level with the eye, the one on the left and the other on the right side. In these views neither upper nor lower surface is visible, but only the front and the one side; and


H
O
L
a

in Fig. 9 the front only is visible, the object being placed directly opposite the eye of the spectator.

Having sketched these several views, or similar ones suggested by these, the sketch is to be partially rubbed out and repeated ; this process is called " lining-in."

This section of our subject will be reverted to in a future lesson ; meanwhile, you are earnestly advised to make constant attempts at sketching the objects around you. Do not say, " Where is the use of drawing from common blocks of stone?" A great sculptor of old said, " Every block of stone contains a statue." We have only to remove the superfluous matter, and depend upon it the knowledge, and consequently the power, you will obtain by drawing these solid forms, will enable you to delineate those of a far higher and more complicated character ; and you must bear in mind that, however gracefully your work may be decorated, unless the object be correctly represented the ornamentation will only be misplaced.

MASONRY.

LINEAR DRAWING BY MEANS OF INSTRUMENTS—(*continued*).

PLATE XI.

THE method of constructing simple scales having been given in " Building Construction," it is not necessary here to repeat the instructions ; the subjects in this plate are drawn to the scale of half an inch to the foot. It is advisable to draw the scale on each sheet, as by measuring from this, instead of from the rule, the trouble of calculating how many inches so and so many of the fractions make is avoided, and generally greater accuracy is obtained.

As a portion of the present study consists of brickwork, the following brief extract from " Building Construction " is given in order to remind the student of drawing for masons of some particulars, which thinking that they did not specially concern him, he may have merely glanced over whilst reading the volume treating of the subject generally. The whole subject of brickwork is, however, discussed in a separate volume, "Drawing for Bricklayers."

"Bricks may be considered as artificial stones, and seem to have been used from the very earliest period in the history of man. Their average size in this country is a trifle less than 9 inches long, about 4¼ inches wide, and 2¼ inches thick.* Their uniformity in size enables builders to describe the thickness of walls by the number of bricks extending across them, thus a slight brick partition wall, being formed of bricks lying on their broad side, with their length in the direction of that of the wall, is called a 'half-brick thick,' its depth from one side to the other being 4½ inches. A wall in which the length of a brick extends through the thickness is called a 'one-brick thick.' A wall 14 inches through is called a 'brick and a half-thick,' though, to speak more accurately, it would be 13½ inches—that is, 9 for the whole brick, and 4½ for the half. An 18-inch wall is said to be a 'two-brick thick,' and so on."

Fig. 1 in this plate is the elevation of the lower part of a window, showing the window-sill.

It will be seen that the wall is built in old English bond, and that the stone sill is equal in height to two courses of brickwork. The opening of the window is 4 feet wide; the brickwork covering the ends of the sill to the width of 2 inches on each side. It will also be observed that in order to avoid the joint in the courses of bricks at the sides coming immediately over each other (which would occur if two bricks placed as headers were laid upon one stretcher), cut bricks, called "closers," are used. This has been explained in "Building Construction."

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* See page 35.

Fig. 2 is the section on A B, and shows the manner in which the sill is sloped off, or "weathered," and throated underneath. Both of these terms will be explained in connection with the next figure.

Fig. 3 is a section of a coping. This term is used for the series of stones used as the capping or covering of a parapet or wall. The name is generally applied to a plain, slightly projecting course, and *cornice* to a larger moulded coping.

Copings are worked with a plain, horizontal bed, two vertical faces, and an inclined or "weathered" upper surface, either forming an obtuse angle with the inner and narrower face, and an acute angle with the outer wider face, or slanting off from the middle towards each side, which latter is technically termed a saddle-back coping. In both cases they are made to project over the wall or parapet on both sides, and in the projected part of the bed under the edge or edges towards which the inclination is given, a channel or groove, called a "throat," is cut, to intercept the water in its inclination to run inwards towards the wall. To protect the separate stones of a coping course from the danger of being displaced by high winds or other accidental causes, and to form a chain through its whole length, the stones are linked together by cramps of copper or iron let into them and run with lead. These metals, however (says Mr. Hoskings,) especially the iron, for the most part act very injuriously from their exceeding susceptibility of atmospheric changes, and their greater or less tendency to oxidation; indeed, the stone invariably suffers more than the work benefits from the metal cramps. Tenons, dowels, joggles, or dovetails of stone, or of hard wood, or cast iron applied so as to be protected from the weather, would be far better, and would answer every desired purpose sufficiently.

A String Course, shown in plan in Fig. 4, and in section in Fig. 5, is meant to protect a set-off in a wall, by projecting over its lower face in the manner of a coping.

The beds are worked parallel, and the outer face vertical, or at right angles to them, but so much of the outer surface as protrudes from the wall is "weathered," or sloped off to carry the water away, and for the reason already stated with regard to copings, the lower bed just within the outer face is throated. A string course cramped or dovetailed in the bed, forms an excellent chain around a brick wall, but the part of it in the wall should be of the exact thickness of one, two, or more courses of the brickwork. The method of drawing these examples is so very simple, that it is not thought necessary to give any instructions on that head.

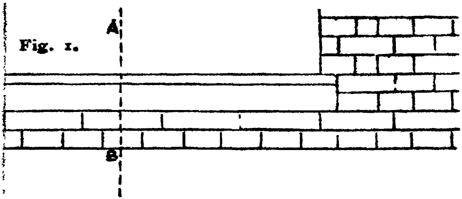
PLATE XII.

The subjects of the present lesson are the plan (Fig. 1) and the sectional elevation (Fig. 2) of a cornice and blocking course.

The **Cornice** is the projecting course at the top of a building, finished by the blocking course. Cornices are but ramified copings, and are or may be subjected to the same general laws. Care must be taken, however, in arranging them, that their centre of gravity be not brought too far forward in the anxiety to project them sufficiently, lest they act injuriously on the wall by pressing unequally, and their own seat be also endangered. A blocking course is either a very thick spring projecting over, or flush with, the face of the lower part of the wall to cover a set-off, or it is a range of stone over a crowning cornice, to bring the centre of gravity more within the wall than it would otherwise be. In the former case it is treated exactly as a string, excepting that if it be flush below, there will, of course, not be any throating; and in the latter it has a horizontal bed, parallel vertical sides,

PLATE XI.

Fig. 1.



Section on A.B

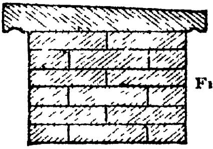


Fig. 3.

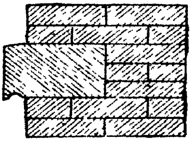


Fig. 5.

Section on C.D

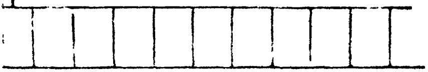
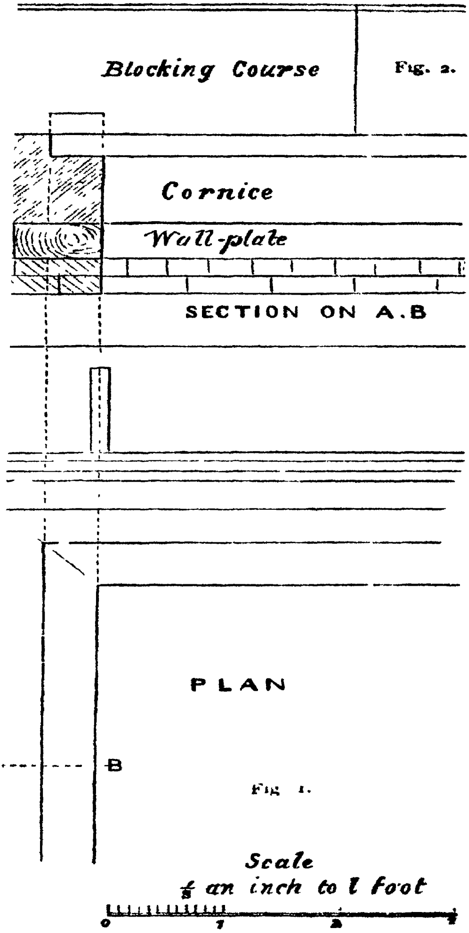


Fig. 4

PLATE XII.


Blocking Course
Fig. 2.
Cornice
Wall-plate
SECTION ON A.B
PLAN
B
Fig. 1.
Scale
¼ an inch to 1 foot
0
1
2
3

and a weathered back or upper surface. With these explanations it is hoped the student will comprehend the drawing and be able to execute it satisfactorily.

PROJECTION. SECTIONS OF CUBES.

PLATE XIII.

THERE is no branch of projection which is of more importance to stonemasons than that which treats of sections, and it is therefore here proposed to describe and illustrate a few of the forms which are generated by different cuttings of the cube.

It has already been shown in the second volume of this series—“Projection,” p. 112, that if a cube be so placed as to rest on one side of its solid angles, whilst the base is so raised that the diagonal which connects the front angle of the top with the opposite angle of the bottom, the solid diagonal will be a horizontal line, as shown at A B, Fig. 1, and that if the cube be then rotated on the angle C, the front view will be a regular hexagon, shown in Fig. 2. The system of projection on the inclined plane has been fully worked out in “Projection,” p. 43, &c.

Having proceeded thus far, draw the line D C, and let us endeavour to find the true form of the section of the cube which would be thus produced.

It will be evident that the point D, not only represents the one angle of the cube, but that it hides one beyond it, which becomes visible when the cube is rotated on the angle C, as shown at *d* and *d'* in the front elevation, Fig. 2. Now if *d* and *d'* be joined to *c*, the true section on D *c* will be found to be an equilateral triangle.

Returning now to Fig. 1, draw the perpendicular line passing through the middle I of the line D H, and cutting the edge D G in E and *c* H in F.

Having now drawn the plan and projection of the cube shown in Fig. 3, draw a horizontal line from I, cutting the projection, Fig. 3, in *i* and *i'*, also draw horizontal lines from E, cutting the projection in *e e'*, and from F, cutting the projection in *f f'*.

Join *e e'*, *e' i'*, *i' f'*, *f' f*, *f i*, and *i e*, and it will be seen that this section is a regular hexagon. Now draw horizontal lines from the angles of the plan of Fig. 3, and perpendiculars from the angles of Fig. 1, thus obtaining Fig. 4, the plan of the cube when raised on the solid angle. Then draw perpendiculars from I, cutting the plan *i'' i'''*, join *a' i'' b'* and *i'''*, and the lozenge thus formed will be the horizontal section on the line A B.

MASONRY.

LINEAR DRAWING BY MEANS OF INSTRUMENTS—(*continued*).

PLATE XIV.

FIG. 1 in this plate is the elevation of a window with mouldings and cornice.

Fig. 2 is a section of the cornice and traverse on the line A B. This example is very simple in its character, but will test the student's power in accurate drawing, since all the lines of the different members must be truly parallel to each other, and the joints at the angles must be carefully and neatly made.

In commencing this subject, draw the central perpendicular, and set off on it the three parts *a b*, *b c*, and *c d*, representing the three parts—viz., the architrave, frieze, and cornice—into which an entablature is divided.

Next draw the complete rectangle *e*, *f*, *g*, *h*, and set off within it the width *e i*, and *h j*, corresponding with *b a*.

Lines drawn at 45° to unite the inner and outer lines

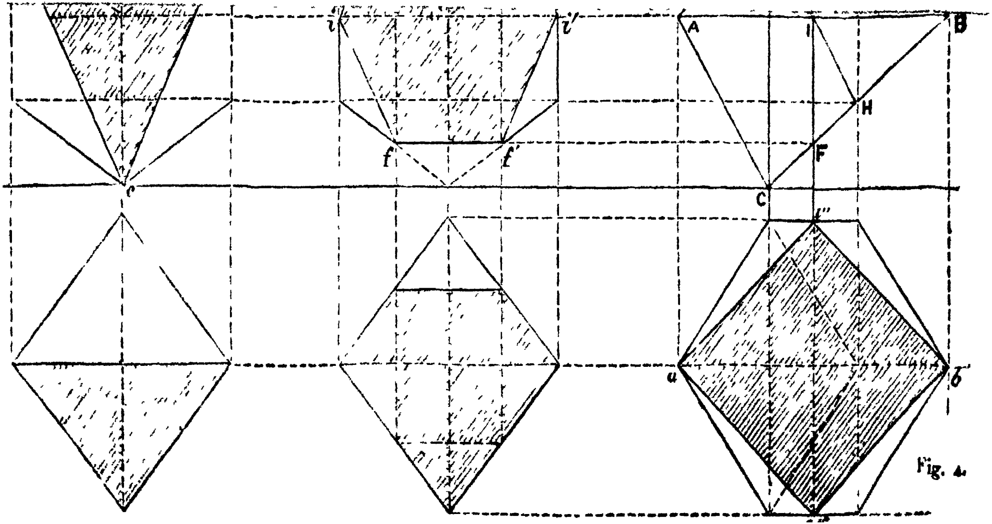


Fig. 4.

PLATE XIV.

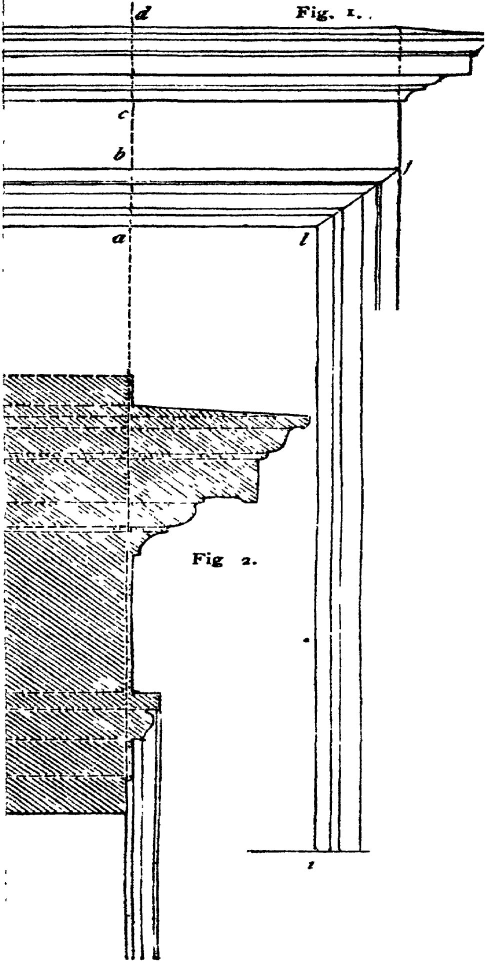


Fig. 1.

Fig 2.

of the jamb with those of the lintel will aid, not only at the present stage, but will be found very serviceable in drawing the mouldings into which the space *a b* is subsequently to be divided.

To draw these separate members, set off the divisions on the central perpendicular between *a* and *b*, and draw horizontal lines through the points of division.

Set off the same points between *e* and *i* and *h* and *j*, and draw perpendiculars through them; these should, if the work be correctly done, meet the horizontals on the lines *f l* and *g k*.

The cornice is now to be completed by drawing the true forms of the ends of the various mouldings of which it is composed. These will be better understood on referring to the enlarged section (Fig. 2), which it is expected the student will, after his previous practice in drawing mouldings, be able to follow without any difficulty.

PLATE XV.

Fig. 1 is a design for a simple Gothic chimney-piece. A chimney-piece is an ornamental addition to one side of a room, surrounding, and with the mantel-shelf surmounting, the fire-place. We say *ornamental* addition, because it is not really necessary, since the aperture containing the fire could be simply walled round without any architectural features to decorate it.

This being so, the chimney-piece should never be too large, but should be in keeping with the size and general features of the room—a consideration often too much neglected.

Chimneys are of comparatively modern introduction, and therefore we have no precedents in ancient architecture, in order to direct our taste in the decoration of this construction, whilst on the Continent the heating arrangements differ entirely from ours; and thus it has been mainly ir

England that chimney-pieces have become special features in interior architecture, the good taste in this department having been introduced by Inigo Jones. Since his time, however, the manufacture of mantel-pieces has become a regular branch of the mason's trade, and owing to the introduction of machinery in working marble, they are supplied at a much cheaper rate than formerly.

The method of drawing this example is precisely similar to that already shown in the last plate. A central perpendicular should be drawn in each pilaster, and the profile of the mouldings must be set off from it. The arch is of the class termed "Segmental"—that is, it is formed of two segments of circles the centres of which are below the springing.

Fig. 2 is a section through the crown of the arch ; the method of projecting this will be easily understood from the example.

FREEHAND DRAWING—(*continued*).

PLATE XVI.

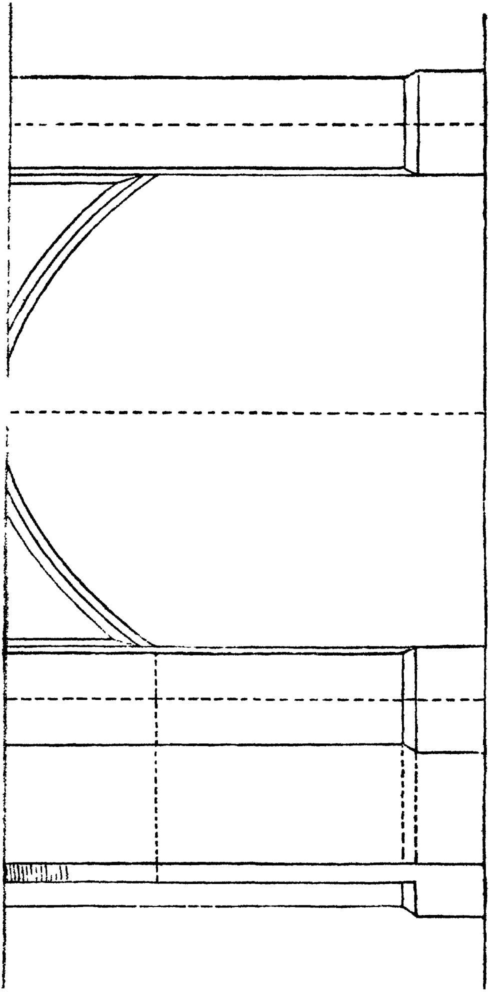
HAVING thus given a series of lessons in linear drawing by aid of instruments, we now revert to the practice of freehand drawing, in order that the various branches of art may be cultivated in due course.

In commencing to copy the example which forms the subject of the present lesson, draw the central perpendicular *a b*, and the three lines *c d*, *e f*, and *g h* at right angles to it.

Next draw the curve *c i*, and the corresponding curve on the right side.

Then draw the curve *e j*, and that commencing at *f*, to balance it, and this is to be followed by *g k* and the opposite curve at *h*.

Now sketch the central leaf at *a*, drawing first the left



nd then the right side. No notice is at this stage to be aken of the indentations in the edges of the leaf, the vhole of which is to be sketched in dotted or very fine ines, as shown at *l m*, and *n o*, in the example.

In the same manner sketch the general outline of the eaves *l m*, *n o*, *p q*, and *r s*. It will be seen that the leaf overlaps *o* in the middle; the underneath portion of *o*, vhich is covered by *n*, should, however, be carefully ketched, as by continuing it the upper portion of the leaf is drawn.

The whole design having thus been outlined and corected, the indentations of the leaves are to be drawn. he exact places for the points should be marked before ommencing to draw them, otherwise it is likely that ither too much or too little space may be found for the equired number of indentations.

When the entire sketch has been completed, it is to be artially erased and "lined in."

PROJECTION—(*continued*).

Sections of Cylinders.—We now revert to the subject of sections, the importance of which has already been pointed out.

PLATE XVII.

In this plate the method of obtaining various sections of a cylinder is given. The subject of the projection of cylinders and their sections has been treated of generally in connection with Plates XXIII. and XXIV. in "Projection," and it is proposed to extend that instruction in the present lesson.

Let Fig. 1 be the plan of the cylinder, and Fig. 2 the side elevation when placed on an inclined plane.

To draw this elevation, it must be understood that it is the *side* view of the cylinder, viz., that which would be obtained by looking at it in the direction of the arrow shown in Fig. 1, the line A B projected from the diameter will then represent the width of the cylinder, the centre being represented by the point *c*.

Having drawn at *a*, Fig. 2, a line at an angle to the intersecting line corresponding with that of the inclined plane, set off on it *a*, *c*, *b*, draw lines at right angles to *a*, *c*, *b*, and terminate these at the required height by a line *a' b'*, which will complete the general elevation of the cylinder. This would not, however, be sufficient for the projection of a front view of the cylinder; it is therefore necessary to find more points through which the curves may be drawn.

Therefore, divide the plan (Fig. 1) into any number of equal parts, and project these points upon the line A B, viz., D, E, F, G. It must, however, be borne in mind that these letters, as well as C, represent *two* points each; for example, E represents E' and E *the point beyond;* that is, the point lying immediately behind E', and therefore hidden by it. Set off these points on *a b*—viz., *d*, *e*, *f*, *g*—and draw lines from them at right angles to *a b*, the line *c c'* being the projection of the axis.

Now from the various points in the plan, draw perpendiculars, and from those corresponding with them in Fig. 2 draw horizontals, which, intersecting, will give the points through which the ellipses forming the projection of the two ends of the cylinder are to be drawn: these being joined by perpendicular lines will complete the front view (Fig. 3).

We now proceed to project a section of this cylinder taken on the given line *c' h;* that is to say, assuming that the cylinder is placed on an inclined plane, what would be the exact shape of a section taken vertically, the cutting plane entering at *c'* and proceeding directly downwards to *h*.

Now it has already been said that the points in the elevation *c*, *d*, *e*, *f*, and *g* each represent two points; *c'* is then the projection of the diameter which is at right

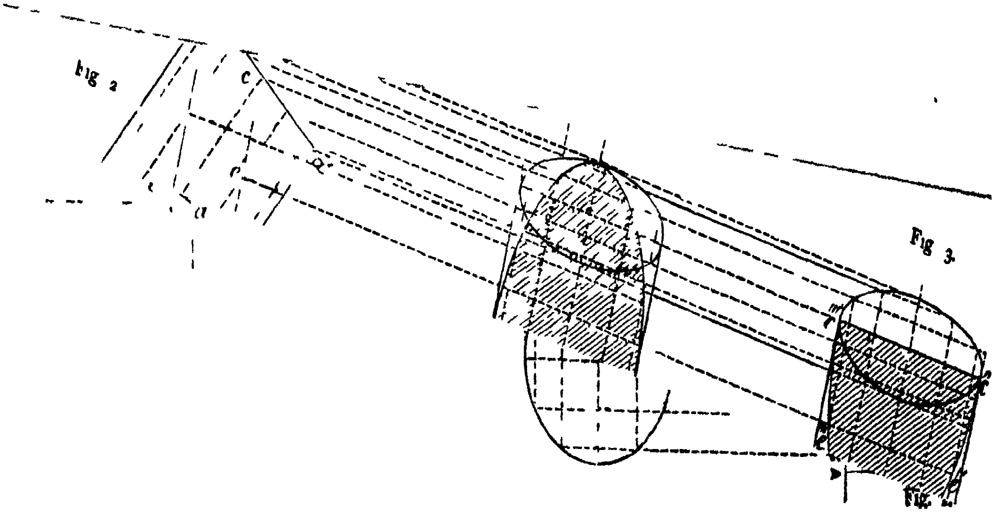


Fig 2
c
Q
c
a
Fig 3
r
m
A
Fig 4

ngles to the vertical plane, and which in Fig. 3 is seen t c'' c'''. The point d in the elevation (Fig. 2) is repre-ented by the line d'' d''' in the projection (Fig. 3), and hus the point h in the one is represented by the point h' n the other.

In the same manner e'' e''', and any number of points, nay be obtained ; the curve c'', e'', d'', h', d''', e''', c''', joined y c''' c'', will then be the true section required.

Fig. 4 shows the true section on the line a b'—viz., that aused by a plane passing from the one extremity b' of he diameter of the top to the opposite extremity of the liameter a of the bottom, the cylinder being so placed hat this section is a vertical one. This is to be pro-ected in precisely the same manner as the last, and there-ore will not require any further comment.

MASONRY.

LINEAR DRAWING BY MEANS OF INSTRUMENTS—(*continued*).

PLATE XVIII.

HE subject of this plate is a niche, standing in a pedestal, nd surmounted by a pediment.

A **niche** in architecture is a cavity or hollow place the thickness of a wall, in which may be placed a gure, a bust, a fountain, &c.

In commencing this example, draw the general outline f the plan (Fig. 1), and project from it the pedestal (Fig. 2) nd body of the whole structure, carrying up the central erpendicular A B. Now, at any convenient distance, raw C D parallel to A B, carry out the lines parallel to he front of the niche to C D, and from C, as a centre, escribe the quadrant D F and E G, and at E erect a per-endicular. Draw a horizontal line in continuation of the top of the pedestal, meeting a perpendicular drawn from F in H. This will give the extreme depth of the pedestal.

Now between F and H construct the exact sections of the mouldings of the pedestal, and, having drawn from these perpendiculars as far as the line E F, draw quadrants from these points, using C as the centre; these quadrants meeting G D will give the points from which horizontal lines are to be drawn, which will be the plans of the mouldings, parallel to the back of the object; these meeting lines, drawn at the angles at 45°, will give the points at which the mouldings at right angles to the front are to be drawn.

From the points of intersection at these "mitres" perpendiculars are to be drawn, meeting horizontals drawn from the corresponding points between F and H, and thus the mouldings of the pedestal in Fig. 2 will be projected.

The horizontal section on the line I J is now to be added in the plan, and the elevation of the niche projected from it.

It is now advisable to draw the true section of the pediment, in order that the elevation may be projected from it. The forms of the various members, and also the upper part of the niche, will be understood from the example, and when these have been completed, their heights are to be projected on to the central perpendicular A B, and through the points the horizontal and raking mouldings of the pediment are to be drawn. The upper surface of the pediment may then be carried down to the plan, as shown by the dotted lines.

The same method is to be followed in projecting the side elevation, Fig. 4, from the plan and front elevation.

PLATE XIX.

Fig. 1 in this plate is the elevation of a semicylinder arch, the planes of which are vertical, parallel, and at right angles to the axis. No difficulty will be experienced

in drawing this figure, the form of the arch under these conditions being a semicircle, the joints of the voussoirs converging to the centre.

Fig. 2 is the plan of the whole structure.

Fig. 3 is the sectional elevation, caused by a plane standing on the axis in the plan, thus giving a complete section of the keystone, and leaving the intrados of the arch in elevation.

Fig. 4. This figure is a development of the intrados of the arch. The student is reminded that to obtain this, the entire curve must be divided into a number of parts, and these set off along a straight line.

Another important lesson is, however, given in this—viz., the method of obtaining the exact shape of the templets for the sides of the various voussoirs—a matter of very great importance in stone-cutting—each laid down flat on the line at which it would meet the intrados.

Having found this place $a'\ a''$, measure the exact length of the side of the voussoir in the elevation—viz., $a\ c$ (the line common to the keystone and the first voussoir), and set off this length on the plan from a'—viz. $a'\ c'$, and draw $c'\ c''$, then the rectangle $a'\ a'\ c''\ c'$ is the shape of the templet required for the two sides of the keystone A, and one side of the voussoir B ; the templets for the other voussoirs are obtained in the same manner.

Figs. 5, 6, 7, and 8 are simple projections of the various voussoirs. These are delineated by a method even simpler than isometrical projection, to which study practice such as this forms a most easy step. This system—if, indeed, anything so simple can be called a system—is much used on the Continent, and at once recommends itself to working men from the ease with which solidity is given to otherwise flat elevations. To speak of *theory* is out of the question, the best teaching will therefore consist in the practice.

Fig. 5. Let a, b, c, d be a correct copy of the end elevation of the keystone, as in Fig. 1, the arc $a\ b$ being struck with the radius of the arch $o\ a$, and the sides of the voussoir being produced to o, so as to form a complete wedge.

Now, placing the T-square so that its cross end may work against the left side of the drawing-board, draw the lines $c\ c''$ and $d\ d'$ by means of the set-square of 45°, set off on d and c the real depth of the block by scale, and join $c'\ d'$.

Find e, the middle of $c'\ d''$, and from e draw a perpendicular.

From o draw a line parallel to $d\ d'$, viz., $o\ e'$. Draw $c'\ e'$, $d'\ e'$, which will give the distant end of the wedge.

From e', with radius $o\ a$, describe the arc $a'\ b'$.

This will complete the keystone.

The other voussoirs (Figs. 6, 7, and 8) are delineated in the same manner, and will be easily understood from the plate.

PLATE XX.

This plate is repeated from "Building Construction," so as to serve as the immediate guide to the following study. The student is, however, urged to refer to the volume alluded to for a full working out of the projection of arches at given angles to a roadway.

Here A B C D (Fig. 1) is the plan of a building to be covered by a groined roof.

The arch, the springing of which is A B and C D, is a semi-cylinder.

The arch, which has it springing in A C and B D, being of the *same height*, but wider span, is a semi-*cylindroid.*

A cylindroid is a solid body of the character of a cylinder. But whilst in a cylinder all sections taken at right angles to the axis are circles, in the cylindroid all such sections are ellipses. It is, in fact, a flattened

nder, the curve of the groin that is generated by the etration of a cylindroid and cylinder.

On A′ B′ describe the semicircle (Fig. 2), which repre-nts the form of the arch at the ends A B and C D, and ide it into any number of equal parts, as a, b, c. It is ly necessary to use the quadrant, as throughout the rking the measurements are the same on each side.

Draw the diagonals A D and B C. From a, b, c, d, e, f aw lines perpendicular to A B, and cutting the diagonal D in a', b', c', d', e', f', and set off the same distances on other half of the diagonal. From these points draw es at right angles to A C, and passing through it in ints 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11; mark off on the rpendicular 6 the height 6 f equal to the height of the micircle at f, and on the perpendiculars 5, 4, 3, 2, 1, rk off in succession the heights of the perpendiculars d, c, b, a, as contained between the semicircle and its ameter. Set off the same heights on the corresponding rpendiculars on the other side of 6 f, and the curve ced through these points will be the semi-ellipse, which the section of the semi-cylindroid forming the arch of ich A C and B D are the springings.

We now proceed to find the curve of the groin, and it ll be evident that although the span is still further creased in length, the heights of the different points in e curve will be the same as in the corresponding parts both the previous elevations.

The span, then, of the arch at the groin is the diagonal D (or B C), to which the divisions a', b', c', d', e', f' have eady been transferred from the semicircle; and from se the lines were carried at right angles to A C, on ich the heights of the points in the curve were off.

These points on the diagonal, then, will be seen to be mmon to both arches, since they are the plans of the points in the roof where the cylindrical and cylindroidal bodies penetrate each other.

At these points, therefore, draw lines perpendicular to the diagonal, and mark off on these the heights of the perpendiculars in the semicircle from which the points on which they stand were deduced.

These extremities being connected, the curve so traced is the groin curve, and will give the shape for the centering for the groin, as the semicircle and semi-ellipse will for those used in the elevations of the arches.

It now only remains to develop the soffits, or under surfaces, and we commence with the *semi*-cylindroidal arch.

Fig. 2. Draw any straight line, and commencing at A, set off on it the distances into which the curve A C is divided (measuring *on* the *curve*, *not* on the springing line), viz., the distances A, *a*, *b*, *c*, &c. At the points on the straight line thus marked, draw perpendiculars; make the middle one equal to 6 *f*, those on *e e* equal to 5 *e*, those on *d d* equal to 4 *d'*, those on *c c* equal to 3 *c'*, those on *b b* to 2 *b*, and those on *a a* equal to 1 *a'*. Join the extremities of these perpendiculars, and the two curves meeting in a *point*, and joined by the original straight line, will form the development of the soffit of the cylindroidal arch.

Fig. 3 is the development of the *semi-cylindrical* arch. As this is worked in precisely the same manner, from the *semicircle*, no further instructions are deemed necessary.

PLATE XXI.

The examples here given form applications of the previous lesson, and give the principles of the lines concerned in a groined roof, called in French *Voûte en Arc de Cloître.*

Fig. 1 is the plan of an oblong chamber, Fig. 2 (A B C)

PLATE XX.

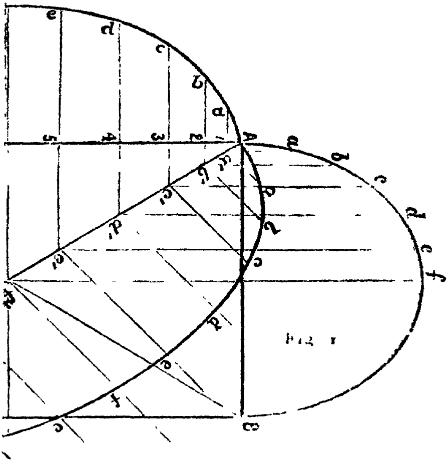


Fig. 1

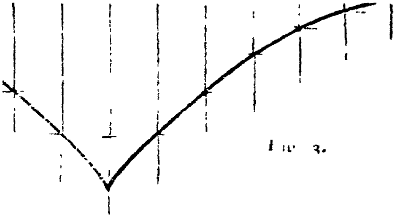


Fig. 3.

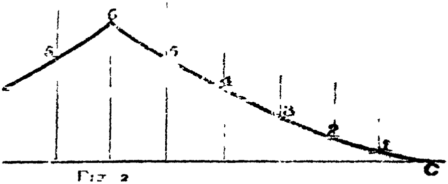


Fig. 2

is the transverse and Fig. 3 (A′ B′ C′) the longitudinal section, the section at the groin being shown on one of the diagonals, as in the previous study.

It will be seen that the extrados in Fig. 2 is eccentric. The method of drawing this has already been given in Plate III., Fig. 2.

The points of division of the voussoirs (F, G, H, Fig. 2) having been projected on the diagonal of the plan, viz., f, g, h, and from these to the longitudinal section, viz., F′, G′, H′, &c., the next process is to find the joints in this semi-elliptical arch.

For this purpose it is necessary to find the *foci* of the semi-ellipse.

A′ C′ is the long diameter, and O B′ is half of the short diameter.

From B′ (the extremity of the short diameter), with the length O A′ (half of the long diameter), describe arcs, cutting A′ C′ in F F, the foci of the ellipse.

From both foci draw lines to each of the points of division, as shown at G″, and bisect the angles thus formed. The bisecting lines will be the required joints. For further working out of this study, see "Linear Drawing," Fig. 90.

Now, to terminate these by the extrados, produce the base-lines of Fig. 2 and Fig. 3, intersecting each other in X, and forming the right angle W X Y.

From the points *f′*, *g′*, *h′*, *b″* in the extrados of Fig. 2, draw lines parallel to the base-line, and cutting the line X Y in 1, 2, 3, 4.

From X, with radius X 1, X 2, X 3, X 4, describe quadrants, cutting the line W X in 1′, 2′, 3′, 4′.

From these points draw lines parallel to the base-line of the longitudinal section, which, cutting the lines forming the divisions of the voussoirs, will give the points through which the extrados is to be drawn.

DRAWING FROM SOLID OBJECTS—
(continued).

PLATE XXII.

THE present study is one of exceeding simplicity, but one from which the student may obtain great instruction, and he is therefore urged not to copy the drawing only, but to place slabs and blocks of stones in similar positions, and sketch them from various points of view.

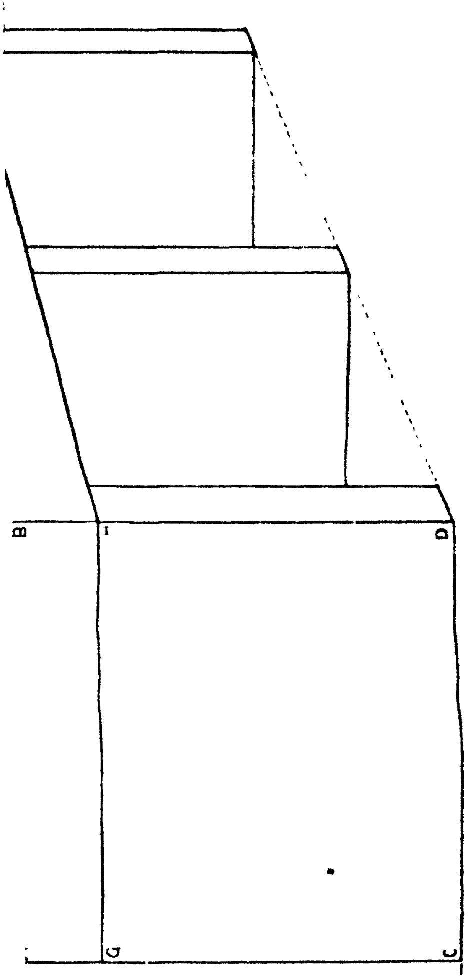
By this system he will learn the practical application of the lesson, and will be able to use the knowledge he acquires in his daily occupation.

The subject is a slab of stone resting horizontally on three others placed on their edges.

It must be here impressed on the student that it is important that he should acquire the habit of sketching all objects in the broadest manner; that he should, as it were, *not see* the details until he has drawn the object as a whole. He should, in the first place, think of it as merely the packing-case in which it might just be contained, or as if all the apertures or vacant spaces were filled up; for it must be clear to any thinking mind that all interior forms, and all detail, must be dependent on the general outline of the whole.

In commencing the subject of the present lesson, draw the rectangle A B C D, which represents the end of the whole block, and which, since it is supposed to stand parallel to the picture, will retain its original shape.

From A, B, D draw lines to the point of sight, which point, however, need not be shown in the drawing, in order that the object may be drawn as large as possible. The back line E F will terminate the horizontal slab, and a perpendicular line from F will complete the general outline of the block.


B
I
D
G
C

Having placed the drawing upright, so as to obtain a just view of it, and having made any corrections which may be deemed necessary, the student will now draw the line G H, and from H the line H I, which will give the thickness of the slab, bearing in mind that the line H I must, like B F, converge to the point of sight.

The widths of the edges of the three slabs on which the upper one rests are now to be drawn, observing that although they are all three supposed to be of equal thickness, they must each of them be diminished as they recede. The slightest observation will have shown that all objects appear smaller and smaller as they become more distant, and this effect is visible, whatever may be the size of the object. The horizontal line at the bottom of each of the slabs will be observed to be partly hidden. This would of course depend on the width of the slabs and the position of the spectator.

The principles of shading objects are given in another volume of this series devoted specially to the subject of Object Drawing, and to this the student is referred for more detailed information.

MASONRY.

LINEAR DRAWING BY MEANS OF INSTRUMENTS—(*continued.*)

PLATE XXIII.

In this plate are given the plan, elevation, and section of a stone arch. The drawings are so self-explanatory, that it is hoped the student will be able to follow them with but little instruction.

The plan (*Fig. 1*), or rather the general outline of it, should be drawn first, and then as much of it added as is shown in section, representing the exact ground on which the abutments rest.

From this it will be seen that the soffit of the arch is in the first place splayed off, next proceeds at right angles to the elevation, then a flat border, and finally the true soffit of the arch.

In order to project these members, three semicircles (Fig. 2) are required, the centres and radii for which will be obtained by projection from the plan, as shown in the example. When these semicircles have been drawn, they are to be divided into the required number of equal parts, radii are to be drawn, and the elevation completed.

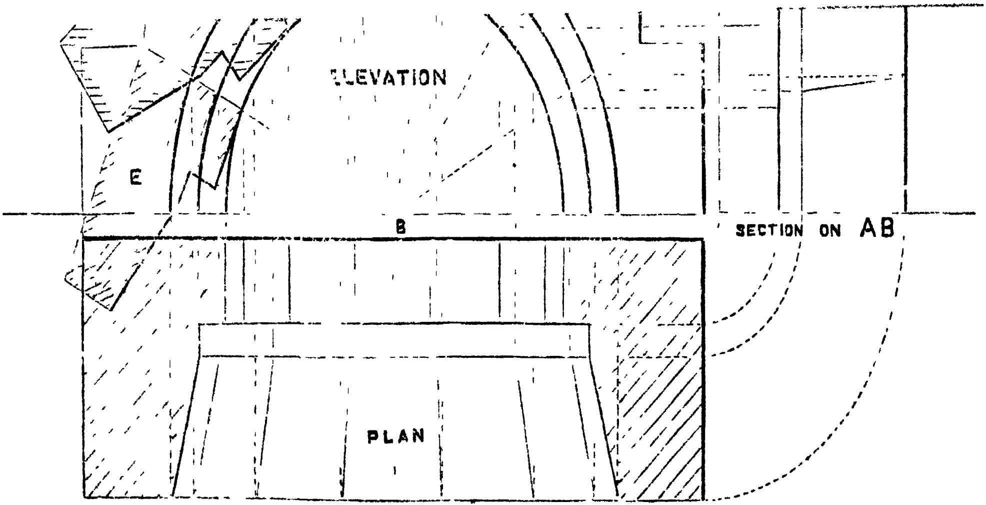
These radii, cutting the three semicircles, will give the points from which perpendiculars are to be drawn, cutting the lines which are the plans of the respective semicircles, and by this means the plan of the soffit will be obtained.

Fig. 3 is the section of the arch through the line A B. The method of drawing this figure has been shown in Plate XXI.—viz., describing quadrants so as to project the widths in the plan, and raising perpendiculars, drawing horizontals from the corresponding points in the elevation to intersect these. The whole of this will be clearly understood from the figure.

Returning to Fig. 2, it will be seen that the templet for cutting each of the voussoirs is given. As all these are projected in the same manner, it will be sufficient to show the working in a single case—viz. C.

From the points where the radius of the one side of the keystone cuts the inner semicircle and the uppermost edge, draw lines at right angles to the radius ; make the top and bottom lines equal to those shown in the section.

The width of the front of the voussoir—that is, the length of the end line which is at right angles to the top —is regulated by a line drawn at right angles to the radius from the point where it passes through the outer circle,


ELEVATION
E
B
SECTION ON AB
PLAN

(along the mid-rib), the one half bears a most striking resemblance to the other ; on the one side the veins run to the right, on the other to the left—perhaps those to the right are a little above those to the left, in that case the difference is maintained throughout. If there are four ribs on the one side there are four on the other ; and if you measure them off, provided the leaf has met with no accident, the one vein is as nearly as possible of the same size as the other. If you place the edges against each other, their little indentations will almost fit. In all plants there is the same remarkable correspondence between the opposite sides or contiguous halves of the same leaf." The example here given is a portion of an acanthus leaf, in which this beautiful symmetry is well displayed.

In drawing this, the curve (A) forming the mid-rib A should be drawn first. It will be seen that this is interrupted at B by the portion of the leaf which turns over and covers it. The line should, however be carried on to *c*, as if the leaf were transparent, so as to form a guide for placing D, which is the inner edge of the mid-rib ; this, if carried on, should fall within B A.

The separate parts of the leaf are to be drawn in masses, as shown by the dotted lines, the separate indentations being drawn when it has been ascertained that the general containing forms are correct.

In order to gain additional practice, the student should copy this example when the plate is turned in various positions.

OF STAIRCASES.

STAIRCASE (stair, derived from the Saxon word *stæger*, to *climb* or *rise*), is a term applied to the whole assemblage of members with the walls supporting the steps

leading from one storey to another. The same staircase is often carried up throughout the whole height of the house, and may be said to consist of as many storeys as the building itself.

When the height of the storey is considerable, resting-places become necessary; these go by the names of "quarter-spaces" and "half spaces," according as the passenger has to pass a right angle, or two right angles; that is, as he has to describe a quadrant or a semicircle.

In very high storeys, that admit of a sufficient head room, and where the space allowed for the staircase is confined, there may be two revolutions in the height of one storey, which will lessen the height of the steps; but in grand staircases, only one revolution can be admitted, the length and breadth of the space on the plan being always proportioned to the height of the building.

The breadth of the steps of stairs in general use in common dwelling-houses is from 9 to 12 inches, or about 10 inches as the medium.

In the best staircases of noblemen's houses or public edifices, the breadth should never be less than 12 nor more than 18 inches.

Straight stairs are such as ascend in a straight line, and consist only of plane surfaces.

Winding stairs are those which turn around either a solid newel, or circular well-hole, the latter either enclosed in a complete cylindrical case, or semi-cylinder, at one end, adjoining to two parallel walls which terminate on an opposite wall.

In winding stairs, the steps are formed narrower next to the well-hole than at their other ends where they are built into the wall. These are termed *winders*.

Those steps which continue of the same breadth are termed *flyers*, in contradistinction to the winders.

Stone geometrical stairs have the outer end fixed in the wall, and one of the edges of every step supported by the edge of the step beneath it, and constructed with joggled joints, so that they cannot descend in the inclined direction of the plane, nor yet in a vertical direction; the sally of every joint forms an exterior obtuse angle in the lower part of the upper step called a "back rebate," and that on the upper part of the lower step, of course an interior one; and the joints formed of these sallies is called a "joggle," which may be level from the face of the risers to about one inch from the joint. Thus is the plane of the tread of each step continued one inch within the surface of each riser, and the lower part of the joint is a narrow surface perpendicular to the inclined direction or soffit of the stair at the end next to the newel.

The stone platforms of geometrical stairs—viz., the landings, half-spaces and quarter-spaces—are constructed of one, two, or several stones, as they can be procured. When the platform consists of two or more stones, the first platform stone is laid on the last step which is set, and one end is "tailed in" and wedged into the wall. The next platform stone is joggled or rebated into the one set, and the end also fixed into the wall, and thus with every stone in succession until the platform is completed.

If there is occasion for another flight of steps the last stone of the platform becomes the spring stone for the next step, and the joint is to be joggled as well as those of the succeeding steps, in the same manner as in the first flight.

Geometrical stairs executed in stone depend, says Mr. Nicholson, on the following principle—viz., that "every body must at least be supported on three points placed out of a straight line, and, consequently, if two edges of one body, in different directions, be secured to another, the two bodies will be immovable in respect to each other."

This last is the case in a geometrical stair; one end of a step is always tailed into the wall, and one edge either rests upon the ground itself, or on the edge of the preceding step; the stones of a platform are generally of the same thickness as those forming the steps.

PLATE XXV.

In this plate Fig. 1 is the plan, and Fig. 2 is the elevation of a stone staircase, in which are exhibited the peculiarities in construction already referred to. We shall point out these whilst proceeding with the drawing.

Draw the plan of the walls (Fig. 1), and from the middle of these draw the lines *a b*, *c d*, and *e f*, equal to the breadth of the steps. Mark off the depths of the steps, and draw the lines which will be the plans of the edges *d g h c*, *b i j k l m n o p q r s t u v w a*, *e x y f*. The quarter-spaces will still be left in the corners, and of these the one is divided into five *winders* leading to the *flyers*, which ascend to the quarter-space. To draw the winders, produce the lines forming the edges of the steps *b* and *c*, until they meet in A. Then from A, with radius A *b*, describe the quadrant connecting the lines *d c* and *a b*. The same radius will also give the quadrant at the opposite end.

Now from A, with any radius describe the quadrant B, and divide it into five equal parts; through these points draw lines converging to A, which will complete the plan of the winders.

In the other angle there is really a quarter-space, and from this four steps rise, the last of which is the landing.

It will be seen that the steps are built into the wall; this is shown by the dotted lines in the plan. The lowest one also rests on the ground, and this supports the length of the one above it, on the principle already explained.

the stairs fitting on each other by the joint called a "*joggle*," shown at *a b* in Fig. 3.

The flat surface of a stair is called the *tread*, and the upright face is termed the *rise*.

The slabs forming the passage, seen in section at X, in Fig. 2, are joined, as shown in the enlarged section, Fig. 4. They, too, are built into the wall at their inner edge, and the passage is further supported by a cantaliver, or bracket, as shown in the elevation.

Fig. 5 shows the mode of describing the curtail, or lowest step, drawn to the scale of 1½ inch to the foot.

Draw A B equal to the width of the visible portion of the tread of the step, namely, 11 inches by scale, an inch and a half being covered by the step above.

Bisect A B in C, and divide C B into four equal parts. On the bisecting line construct the square C D E F, the side of which shall be equal to any one of these four parts.

From C, with radius C B, describe the quadrant B C. From D, with radius D G, describe the quadrant G H; and from E, the quadrant H I, which will complete the spiral.

From I draw a perpendicular, and make I J equal to I E. From J, with radius J I, describe the quadrant I K; and from K the straight end of the step will be drawn, as shown in the general plan. The projection of the elevation of the steps is so simple, that but little explanation will be required.

Having projected from the plan, the mere vertical sections of the walls supposed to be cut through, draw any perpendicular, as C, and on it set off the heights of the risers. This height is, of course, regulated by the space at the disposal of the architect, and the height of the floor to be reached. In this case an average height of rise is taken—that of six inches.

Letter each of these points to correspond exactly with

the figuring of the edges of the steps in the plan. (It will be seen that, in order to avoid crowding, the figures belonging to the winders are placed on the lines instead of at their extremities.) Now from the points marked on the perpendicular in the elevation, draw horizontals, and from the points at the extremities of the edges of the steps in the plan draw perpendiculars ; then the right angles formed by the intersections of the lines similarly lettered, will give the end elevations of the stairs. All other guidance may be obtained by careful study of the diagrams.

Of Winding Stairs.*

The Helix.—The line of a staircase which winds round a well, or which is supported by a central newel, is called a Helix, and although some information as to the construction of this curve has been given in " Projection," some portion of such lesson is repeated here to save reference, and in order that further practice may be the more readily grafted upon it.

It will be remembered that if a piece of paper of the form of a right-angled triangle be rolled round a cylinder, the hypothenuse, or long side of the triangle, will generate a curve winding round the cylinder like a corkscrew. This curve is called the Helix.

PLATE XXVI.

To describe a Helix.—Let the circle A, G (Plate XXVI.) be the plan of the cylinder around which the line is winding. Let the dotted perpendiculars A′ and G represent the elevation, and let the distance A′ to A I, be the height which the curve has reached when it has travelled once round the cylinder, so as to be exactly over the point from which it started. This is called "one revolution," and forms what is called the "pitch"—that is, the distance from thread to thread in a screw.

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* For various methods of constructing spirals, see " Linear Drawing," Figs. 96, 97, and 98.

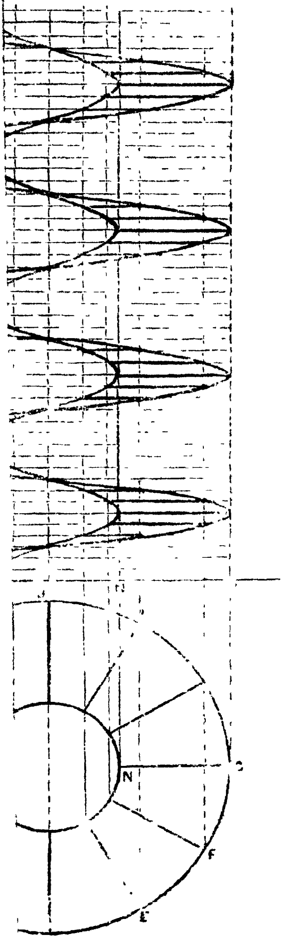
Divide the plan into any number of equal parts, as A, B, C, D, &c., and divide A' A 1 into the same number—viz., *a*, *b*, *c*, *d*, &c. Draw horizontals from *a*, *b*, *c*, *d*, &c., and perpendiculars from the corresponding points in the plan; then the intersections of B with *b*, and C with *c*, &c., will give some of the required points.

Now it will be seen that the points H, I, J, K, L in the plan are immediately at the back of B, C, D, E, and F, and therefore the same perpendiculars will pass through them; and thus, the intersections of these lines with the horizontals correspondingly lettered will give the remaining points required for the formation of the curve. Through all the points thus obtained the curve may be traced by hand.

To continue the Helix, repeat the height of the pitch, as A 2, A 3, A 4; divide the spaces as before, and from the points draw horizontals to intersect *the perpendiculars already drawn*, for it will be evident that the corresponding points in each revolution will be immediately over each other.

Now let us suppose that, instead of a mere line being drawn round a cylinder an inclined plane were to surround the smaller cylinder *m n*. You will, perhaps, understand this better if you cut out of paper the plan A G; cut the smaller circle M N away altogether, and cut through the line A M; place in the hole M N a cylindrical piece of wood of the exact size; keep the edge A M fixed, but raise the edge O P. Then a rising plane or walk would be formed once round the small cylinder, and if this were constructed on a large scale, a person having

ATE XXVI.



travelled along this plane would have reached A I, and be immediately over the point from which he ascended.

Now, a staircase is only an inclined plane on which ledges or stairs are placed to render the ascent easier. For instance, let it be required to reach any height by means of an inclined plane; of course this would be, the more readily accomplished by means of steps on the plane. And it will thus be seen that if steps were placed upon the inclined plane which surrounds the cylinder M N, the principle of a circular staircase would be developed. This principle is further developed in the ensuing plates. The points for the inner curve are obtained by perpendiculars taken from inner ends of the radii cutting the corresponding perpendiculars.

PLATE XXVII.

Let us now see how far the instruction above given applies in the delineation of a winding staircase.

If we stand on the ground and look up from the well of such a staircase, we shall see that the underneath portion of it forms not a line only, but a helical plane, contained between the lower end of the stairs towards the well, and the end where they are inserted into the wall. This plane would correspond precisely with that delineated in the last study; but this is not all. If the edges of the stairs were united, another helical plane would be formed parallel to the last.

A winding staircase, then, is formed by a solid contained between two helical surfaces and two concentric cylinders —viz, the wall and that in which the smaller ends of the stairs are situated. Such a solid is shown in Plate XXVII.

Let A C F be the plan of the well, and K M O the plan of the cylindrical space between the inner ends of the steps, the width M C representing that of the solid in which the steps are contained, their common axis being vertical.

The plan having been divided into twelve equal parts (not *necessarily twelve*), divide the height of one complete revolution into a corresponding number—1′, 2′, 3′, &c. Perpendiculars drawn from 1, 2, 3 in the plan, intersecting horizontals drawn from 1′, 2′, 3′ will give the lower curve A′, 6″, 12′ which it will be seen is hidden by the thickness of the solid when it has passed 6″, but emerges again at 9″.

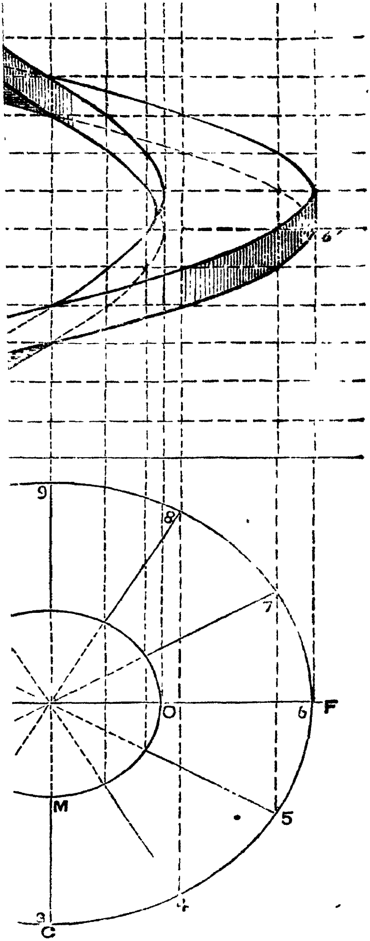
For convenience in the present drawing, the thickness of the solid representing the height of the tread has been taken to be the same as the spaces into which the height of one revolution had been divided. Thus, the second curve, instead of beginning at A, starts from point 1, and throughout the points are taken at one number higher than the previous one; thus the perpendicular from 1 in the plan intersects the horizontal drawn from 2′, and so on. The inner pair of helices surrounding the well are projected in precisely a similar manner from the circle K N O.

PLATE XXVIII.

In this plate is given a portion of the plan of a well staircase, and it is hoped that, after the instruction conveyed by the preceding lessons, the student will be able to draw the whole plan, and project the staircase from it.

Draw the circle A B C (the inner wall of the well), D E F (the circumference of the cylinder on which the inner ends of the steps will be situated), and an additional circle (G H K) in the middle of the length of the steps, on which set off the points *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, the real width of the steps at their middle), this width being measured from *rise* to *rise*.

TE XXVII.



Through these points draw lines (shown in dots in the illustration) to the centre O.

Parallel to these lines, draw the lines a', b', c', d', e', f', g', h' at a distance equal to the width which a moulding would project beyond the rise of the steps, and draw also the circle P R S, in which will be situated the visible ends of the stairs.

It is now advisable to leave the plan for a time in order to draw the true form of the ends of the steps shown in Fig. 2. When these have been completed the widths are to be set off on the circle X Z, as shown from O′ to V′, the figure $o\ o'\ v'\ v$ being the plan of the complete block. If these widths are given in the plan, the sectional elevation may be projected by setting them off on a horizontal line, the heights being marked on a perpendicular; the intersection of these will then give the required forms, as shown in Fig. 2, $o''\ v''$ being the form of the templet.

Fig. 3 is the development of the inner ends of the steps, and w, x, y, z is the templet, which is to be obtained in precisely the same manner.

DRAWING FROM SOLID OBJECTS

(continued).

PLATE XXIX.

In the previous lessons in object drawing, the solids have been considered as rectangular, and we must now proceed to speak of the method of drawing circles and cylinders. We must, however, at the onset, remark that perspective does not deal with circles or other curves as such, but requires that they should be enclosed in rectangular forms. These are then drawn according to their perspective appearance, with the points thus shown through which the curve is to pass. In the case of a circle, the nearest rectangular form which can enclose it is a square, and we will therefore show the method of drawing a circle by this means.

In Plate XXIX. Fig. 1 is a circle which we require to draw when lying horizontally below the eye of the spectator.

About the circle describe the square A B C D, and across it draw the diagonals A D, B C, and the diameter E F and G H. Now proceed to the sketch (Fig. 2). From A and B draw lines to the point of sight; draw C D, representing the distant line of the square; draw the diagonals A′ D and B′ C′, and the diameters E′ F′ and G′ H′. Having proceeded thus far, return to the original figure and draw the lines *e f* through the points where the circle passes through the diagonals—viz., *g*, *h*, *i*, *j*.

Mark off in Fig. 2 from A and B the distance A *e* or B *f* —viz., A′ *e′* and B *f′*, and from these points draw lines to the point of sight. These lines passing through the diagonals give the points *g′*, *h′*, *i′*, *j′*.

Eight points are thus obtained—viz., E′, *g′*, G′, *i′*, F′, *j′*, H, and *h′*. Through these the curve, which is the perspective representation of the circle, is to be drawn.

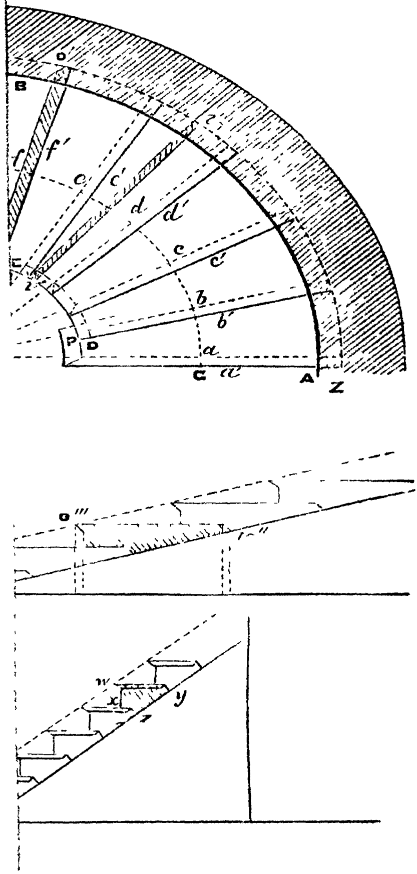
PLATE XXX.

Now, as the *circle* just drawn is shown to be described in a plane square, it is clear that the cylinder would be contained in an oblong block, the ends of which are squares.

Proceed, therefore, to sketch such a block, and guided by the knowledge of the principles laid down in the previous plate, draw the elliptical figures representing the upper and lower ends.

Great care must be taken in drawing the perpendiculars; they must join the curve in a smooth manner, so that no sharp point of junction is visible, and yet the

ATE XXVIII.



ATE XXIX.

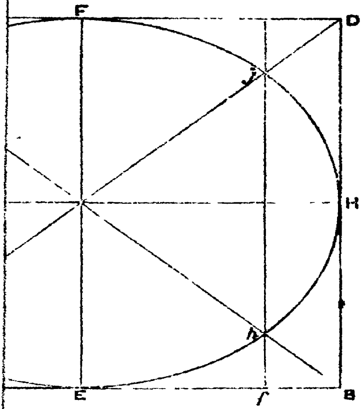


Fig. 1.

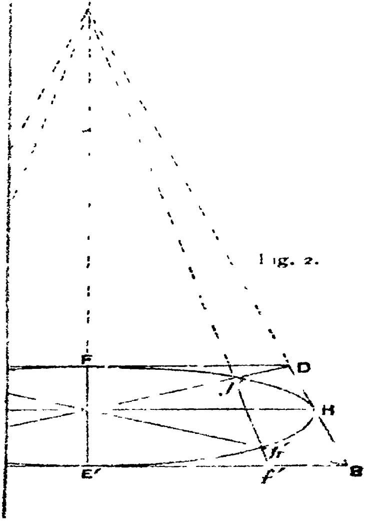


Fig. 2.

object must not appear as if it were rounded off at the bottom, which would give the cylinder an unsafe or sack-like appearance.

It is needless to say that a cylinder placed horizontally would be drawn in a similar method, the position of the oblong being changed according to that of the cylinder.

Fig. 2. This is an octagonal prism, the end of which being parallel to the picture, retains its geometrical shape. Various methods for constructing polygons are given in the first volume of this series, and it is assumed that the student has already acquired this knowledge; if not, he is urgently advised to commence the study at once, as it is the basis of all useful drawing.

The figures in the present study are not, however, intended to be constructed geometrically, but the knowledge of the principles will materially aid in the rapid and correct delineation.

Having, then, drawn the otagonal end, draw lines from the angles to the point of sight, and it will be remembered that the distant end, since it is parallel to the near one, retains its regular shape, and thus no further instruction will be necessary to enable the student to complete this object.

Fig. 3 is a view of a cone. Having drawn the figure containing the base, draw diameters, diagonals, &c., and raise a perpendicular from the intersection.

Trace the curve in the quadrilateral, and draw the lines r the surface of the cone.

It is needless to say that these straight lines enclosing urved forms are only to be used as guides in the early ages of study; but a very little practice will soon enable student to sketch the required form at once, using erely a horizontal or vertical line for the diameter.

whole subject of object drawing is fully treated of in a separate volume of this series, to which the student is referred.

OF GOTHIC MASONRY.

By the term "Gothic" is meant that style of architecture which was in vogue in the Middle Ages, the leading characteristic of which was the pointed arch, although in the early period the arch was semicircular. This style was used principally in churches, and has hence been called "Christian Architecture"—a name which is a correct one, since so many of the forms, ornaments, and details have especial reference to Christianity.

The term Gothic seems first to have been brought into use by the Italians, who applied it to all styles of buildings then prevalent which deviated from the classic. Amongst the first writers who introduced the term into England was Evelyn,* who says: "Gothic architecture is a congestion of heavy, dark, melancholy, monkish piles, without any just proportion, art, or beauty." But so uncertain was he as to what were its real characteristics that elsewhere he describes it as "a fantastical light species of building." Sir Christopher Wren, who it will be remembered did so much for the revival of classic art in England, confirmed the use of "Gothic" as a term of contempt; for, after describing edifices erected after this mode of building as "mountains of stone, vast gigantic buildings, but not worthy of the name of architecture," he says, "this we now call the Gothic manner."

It has been reserved for the present age to revive Gothic architecture, and to show to the world—now more

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* John Evelyn, a distinguished author and traveller, born 1620, died 1706.

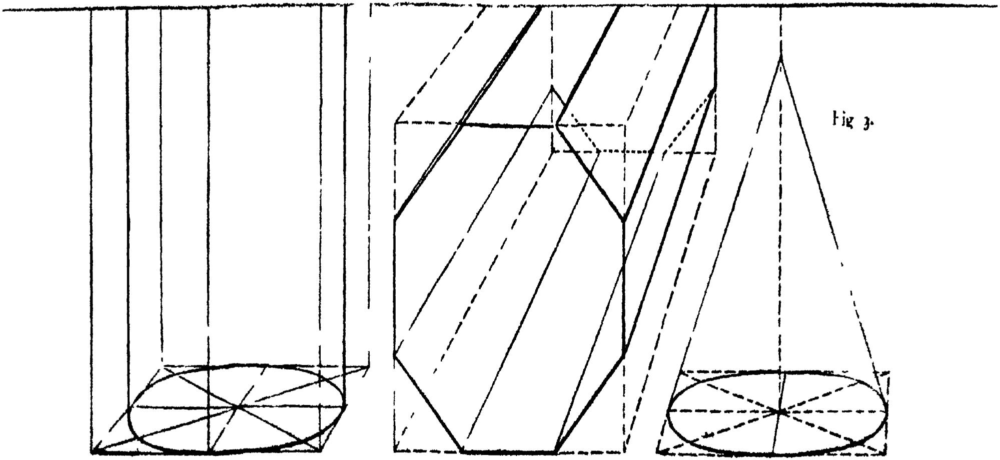


Fig 3.

educated in art—its exquisite beauties, its refined constructive principles, and its picturesqueness. We should, however, bear in mind that the style is essentially religious in its character, and that although varieties of it have been used in domestic and castellated architecture, it is (in the opinion of the author) sadly out of place in the fronts of warehouses, shops, factories, and theatres, and that wherever used away from places of worship, the adaptation should be such as to avoid the desecration of the religious symbols which form some of its most important features.

The development of Gothic architecture in England has been divided into various periods by different authors. We give that by Mr. Rickman as that most generally adopted—

1. The NORMAN style, which commenced about the year 1066 and prevailed to the reign of Henry II. in 1189. It is distinguished by its arches being generally semicircular, though sometimes (in the later period) pointed. The columns or piers exceedingly massive, and the ornaments bold and rude. One of its most characteristic ornaments was the chevron, or zigzag, border.

2. The EARLY ENGLISH style, reaching to the end of the reign of Edward I., in 1307. This style was distinguished by pointed, and hence called "lancet arches," long narrow windows—which were either single or placed close to each other; sometimes the window might consist of two "lights," at others of groups of three, four, or seven lights, the characteristic ornament of the style being a pyramid placed in rows, sometimes perforated, called the Dog-tooth. An Early English window of two lights is the subject of the next lesson.

3. The DECORATED GOTHIC, reaching to the end of the reign of Edward III., in 1377, and perhaps from ten to fifteen years longer. This style is distinguished by its

large windows, which have pointed arches, with tracery in geometrical or flowing lines, not running perpendicularly.

The leading ornaments of the style are (1) the ball flower and (2) a four-leaved flower, both placed in hollow mouldings. The foliage of the Decorated style is designed in direct imitation of nature—ivy, hazel, oak, and other plants or trees being used. This distinguishes it from the Early English, in which the foliage was essentially "stiff leaved."

4. The PERPENDICULAR GOTHIC, the last style which appears to have been used, though much debased, even as far as to 1630 or 1640, but only in additions.

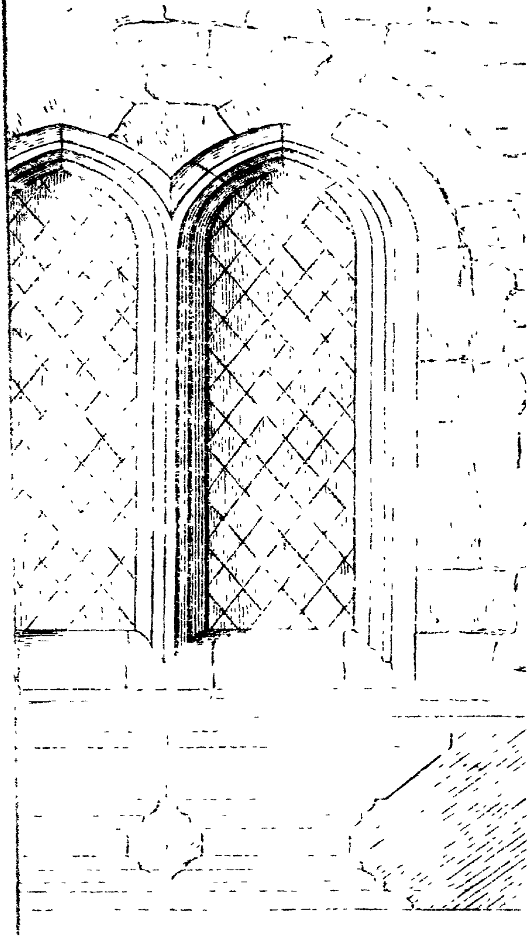
The name clearly characterises this style, for the mullions of the windows and the ornamental panellings run in perpendicular lines, and form a complete distinction from the last style, and many buildings of this are so crowded with ornament as to have received the name of "Florid Gothic," whilst some were so deteriorated in character, with flattened arches, as to have been termed "Debased." The great source of ornament in this style is "panelling;" that is, the manner in which surfaces were covered with decorated compartments. The Tudor flower (excellent specimens of which may be seen in Henry VII.'s Chapel in Westminster Abbey) and angel-headed brackets and corbels were also much used as ornaments.

PLATE XXXI.

This study is a view of a two-light window from the north aisle of Stoke Pogis Church, Bucks. Drawn to scale of ½ inch to the foot.

In this example the plan is to be drawn first, and the jambs and mullions should then be projected by perpendiculars drawn from the plan. The arches are rather

PLATE XXXI.



lower than they would be if the distance from the springing to the apex were the same as the width of the lights; the centres therefore fall between the springings.

It will be seen that the dressings of the window are tooled, whilst the wall is of coursed rubble, strengthened over the window by a relieving arch.

The limits of the present manual preclude further elucidation of this portion of the subject, which will, therefore, be more fully treated of in a special volume devoted to "Gothic Architecture," in which a complete history of the style, with rules and centres for the construction of tracery, will be given. Freehand Drawing for Masons will also be further treated of in a separate volume.

THE END.

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